THURSDAY, SEPTEMBER 18, 1884

THE ZOOLOGICAL COLLECTIONS OF H.M.S. "ALERT"

Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert," 1881-82. (London: Printed by Order of the Trustees of the British Museum, 1884.)

WE need only remind our readers that the *Alert*, under the command of Capt. Sir George Nares, and his successor, Capt. J. Maclear, made a voyage of survey which lasted during the years 1878-82, that the principal parts of the survey were carried on (1) in the region of the southern extremity of the American continent; (2) in that of the coasts of North-Eastern Australia and Torres Straits; and (3) among the groups of Oceanic Islands in the Western Indian Ocean situated between Madagascar and the Seychelles. Dr. Coppinger was the surgeon on board, and it will be always to his credit that while ever attentive to his official duties he succeeded in making and sending home immense collections of marine animals taken by him at the several stations. Those collected off the South-Eastern American continent were reported on in a series of papers published in the *Proceedings* of the Zoological Society for 1881, and were presented to the British Museum. Those from the two other regions were also deposited in the British Museum and reported on by the officers of the Zoological Department, but these reports were, both in their extent and importance, far beyond the scope of any periodical publication, and at the suggestion of Dr. Günther, the Keeper of the Zoological Department, the trustees have published the full account in the form of a separate volume. Irrespective of a number of specimens set aside as duplicates, not less than 3700, referable to 1300 species, were incorporated in the national collection, and of these more than one-third were new additions, if not to science at any rate to the Museum. Well may Dr. Günther write that these "pages are by themselves a lasting testimony to the great service rendered by Dr. Coppinger to the National Museum and to the cause of science."

The exigencies of the service prevented any deep dredgings, so that though many interesting discoveries were made in the western parts of the Indian Ocean, the depths of this region are still waiting to be explored. The account of the collections made at Melanesia form the first 482 pages of this volume. The Vertebrates are reported on by Mr. Oldfield Thomas, Mr. R. Bowdler Sharpe, and Dr. Günther. They call for no special notice; but Dr. Günther takes the opportunity afforded him by the examination of several well-preserved specimens of Branchiostoma in Dr. Coppinger's collection to give a revision of the known species. While at one time inclined to agree with J. Müller that there were no specific differences between Brazilian and European specimens, and even considering specimens from Indian and Australian localities to be referable to the one species, Dr. Günther has now convinced himself that this view is incorrect, and that Sundevall was quite right in drawing attention to the number of myocommas as an excellent taxonomic character. The number can be ascertained even in specimens in an indifferent state of preservation, and varies very little; whilst the extent in depth and length of the delicate fin which surrounds the posterior part of the tail is a much less reliable character, subject to much alteration by the spirit unless great care is taken in the preservation of the specimens. The species may be briefly enumerated as (1) *B. elongatum*, Sund., Peru; (2) *B. bassanum*, G., Bass Straits; (3) *B. belcheri*, Gray, Borneo and Torres Straits; (4) *B. caribæum*, Sund., Rio de Janeiro; (5) *B. lanceolatum*, Pallas, Europe, Atlantic coast of North America; and (6) *B. cultellum*, Peters, Moreton Bay and Thursday Island. A species of this genus is common on the sandy shores of Mahé, one of the Seychelles, but does not appear to have been dredged by Dr. Coppinger.

Mr. Edgar Smith's Report on the Mollusca forms quite a monograph of this group as found in North and North-Eastern Australia: many new species are described, and most of them are figured. The Echinoderms are described by F. Jeffrey Bell. "Though there are no new Echinoidea, there are some very precious series of some species, *Maretia planulata* being notably well represented": 22 species are catalogued. Thirty-one species of Asteroidea are enumerated, 4 being new; and 26 species of Ophiuroidea, four of which are new, and a new genus, Ophiopinax, is established for *Pectinura stellata* of Lyman. Of the Holothuroidea 19 species are mentioned, and 6 are described as new, and figured. As to the Crinoidea, the author acknowledges the help he received from P. H. Carpenter, and details 27 or 28 species. "The proportion of undescribed to described species is no doubt appalling." Of 15 species of Antedon, 12 are described as new; and of 12 species of Actinometra, 4 are described as new, and 2 are recorded for the first time on the manuscript names of Herbert Carpenter, to be more particularly described in his forthcoming Report on the Comatulæ of the *Challenger*.

The Crustacea, reported on by Mr. E. J. Miers, chiefly collected "on the north-western, northern, and north-eastern coasts of Australia, are very numerous, and are interesting not only on account of the large number of new or rare species obtained, but also on account of the careful manner in which, in nearly every instance, the nature of the sea-bottom and the depth of water, &c., were recorded;" 203 species are enumerated, and 45 are described for the first time. The depths seem to have been from off shore to 30 fathoms. Eighteen plates of figures accompany this part of the Catalogue.

The collections of Alcyonaria and Sponges made by Dr. Coppinger are described by Mr. Stuart O. Ridley, whose reports are very welcome additions to our knowledge of these forms. Although not containing deep-sea forms, these collections give a good general insight into the character of the fauna of the shallow waters of the north east and north-western coasts of Australia. The almos absence of forms of Pennatulidæ—only 2 species are re corded, one very young, and the other very imperfect—is hardly to be accounted for by the fact that no greater depth than 36 fathoms was reached with the dredge, as the Pennatulids are by no means exclusively deep-sea forms. Of the fixed forms 36 species are referred to, of which 12

are described as new. The occurrence of two kinds of polyps differing chiefly in size is noted in a new species of Melitodes. The Sponge collection was large, comprising over 300 specimens, representing 110 species, besides 7 distinct varieties, of which more than half were well preserved in spirits; a large proportion—42—were new. More than one-sixth belonged to the Ceratosa, 86 to the Silicea, with no representatives of the sub-order Hexactinellida, and there were but three species of Calcarea. The author deserves great credit for the painstaking way in which he has described every form, so that no doubt might remain as to its character; and where there was the slightest doubt of the form being a new species he has refrained from possibly adding to an already over-burdened synonymy.

The description of the collections from the Western Indian Ocean forms the second part of this volume, and occupies about 150 pages. The reporters are the same as in the previous part. Among the birds, Mr. Sharpe describes a new Turtle Dove (*Turtur coppingeri*) from Glorioso Islands. Mr. Edgar Smith's list of Mollusca "may be regarded as an appendix to E. von Martens's work on the 'Mollusca of the Mauritius and the Seychelles'; of the 121 species noted, between 40 and 50 do not occur in Möbius's work, and the majority of them, as might be expected, are well-known forms." Thirteen new species are described and figured.

Forty-eight species of Echinoderms are tabulated by Mr. F. Jeffrey Bell. The only object of special interest is a remarkable new Ophiurid, for which a new genus, Neoplax, has been established; *N. ophiodes* was found at Darros Island, Amirante Group.

The collection of Crustacea, described by Mr. E. J. Miers, though less numerous in species and less interesting than those obtained on the Australian coasts, contains a large number of rare and undescribed forms, partly owing to the fact that the groups of islands known as the Amirante, Providence, and Glorioso Groups have hitherto been unknown to the carcinologist; 104 species and varieties are enumerated from the African sub-region, of which 16 species are described as new. A useful table showing the distribution of the species on the East Coast of Africa and islands adjacent is appended to this Report.

Mr. C. O. Waterhouse describes a new beetle (*Cratopus adspersus*) from Eagle Island (Amirante), and Mr. A. G. Butler a new moth (*Deiopeia lactea*) from Providence Island (Mascarines).

The series of Alcyonaria and Sponges, as before, are described by Mr. Stuart O. Ridley. The collection of Alcyonarians made was small, not, we should imagine, because the dredgings were limited to depths not exceeding 30 fathoms, but to the difficulties of collecting on and under coral reefs. Probably the same difficulty was in the way of a collection of Zoantharia being made, though notably species abound all around these Western Indian Ocean Islands. Of the 8 species of Alcyonaria, 2 are noted as new. The collection of Sponges was more important, containing as it did 56 species, of which 21 are described as new. In a survey of the species the author notes that, "notwithstanding the large proportion of new specific forms, there is a comparative scarcity of forms showing marked distinctive characters of generic importance which are not also to be found in the more familiar Atlantic fauna." Indeed this western part of the Indian Ocean may be considered, so far as the Sponge fauna goes, as transitional between Australia, South-West Africa, and the Mediterranean.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

The Flow of Streams

THE inclosed notes by my friend Mr. George Maw of Benthall Hall will no doubt interest some of your readers. They were communicated by me to Sir Wm. Thomson, who made the following remarks upon them:—"Mr. Maw's notes are extremely interesting. I lately observed similar phenomena in the streams flowing from the pools on the Burbo Bank near Liverpool. You ought to send them to NATURE."

DEAR MR. SMITH,—As I know you have been making observations on river currents and the effect of friction on the motion and passage of streams, I cannot resist sending you the accompanying notes on a very curious case we met with near the Lake of Thun. It is an extreme illustration of the action of gravitation and friction working, as it were in opposition. I have often observed something of the same kind before, but never so well marked. Looking up the stream from the lake, the effect was just like a long ladder of low waves approaching you, each separately breaking over a low fall into the lake.

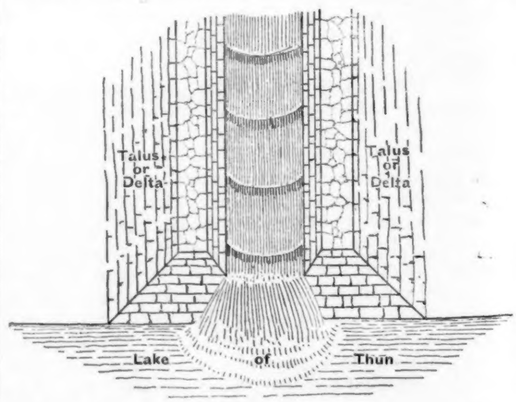
Believe me very truly yours,

GEORGE MAW

Hotel and Pension Ober, Interlaken, June 29

Notes on a Pulsating or Intermittent Stream at Merligen, on the Lake of Thun

The intermittent flow of streams familiar to us, from the rapid pulsation of the cataract to the slower rise and fall at regular intervals of less precipitous streams, is strikingly illustrated in a mountain stream flowing into the Lake of Thun, near Merligen. The lower part of its course over a small talus or sloping delta has been artificially banked up as a straight channel 15 feet wide, evenly paved and walled with stone. The lower part has an inclination of about one in twelve, and the upper part towards the mountain gorge a slope of about one in nine. It flows directly



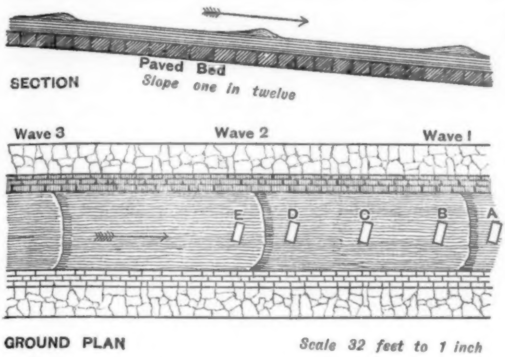
into the lake, and, viewed from the lake, presents a remarkable appearance.

The fall into the lake pulsates at intervals of $3\frac{1}{2}$ seconds by a sudden increase of volume, and the stream above, flowing over

the level paved bed presents the appearance of a ladder of low advancing waves occurring at regular intervals of about 40 feet over the lower slope of one in twelve, and at less regular intervals of about 12 feet over the steeper slope of one in nine.

Of the motion of the stream over the lower slope of one in twelve the following particulars were noticed :—

A floating body travels at the rate of $9\frac{1}{3}$ feet per second, but this does not represent the speed of any part of the water.



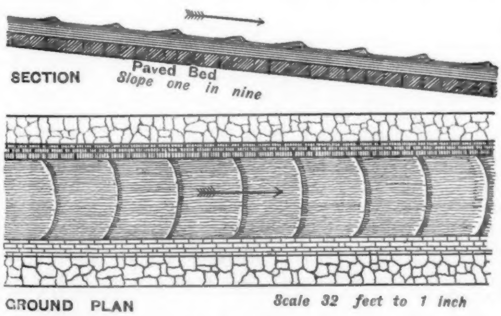
The wave-heads advanced at the rate of 13 feet a second, and the intervening stretches of stiller water (as nearly as I could judge) at about 6 feet a second. It is evident that the upper and lower currents are travelling at different rates—the bottom current retarded by friction, the surface current advanced over it by gravitation, accumulating at intervals of about 40 feet into wave-heads of a semicircular form, the sides being bent back by latent friction.

The motion of a floating body in the stream of advancing waves is very peculiar. A piece of wood thrown in at A, just in front of the advancing wave, No. 1, is *for a moment* carried forward by it, but the slower lower stratum gains the mastery, and the wave advances in front of the wood, which is successively found at B, C, D, E, &c. *relatively* to the advancing wave-heads, the floating wood recedes up the stream, though actually advancing at a rate between that of the upper and under or ground current.

The waves occur at intervals of about 40 feet, and occupy a trifle over 3 seconds in passing over the space that separates them.

Of the motion of the stream over the steeper slope of about one in nine, the following particulars were noticed :—

A floating body travels at the rate of $12\frac{1}{3}$ feet per second. The wave-heads were less clearly defined than on the less steep

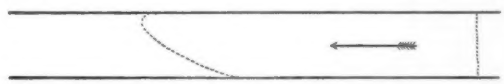


incline, and it was difficult to accurately measure their rate of advance, but as in the other case they rapidly overshot a floating piece of wood. They occur at much shorter intervals (about 12 feet) than on the less steep incline. GEORGE MAW

Interlaken, June 28

I may mention that my observations referred to by Mr. Maw were made upon the current of the River Severn with a view to explain the cause why the men who navigate the barges, in descending this river by the force of the current only are enabled to steer with a moderate degree of effectiveness. The power results from the different velocities of the current at and beneath the surface. A little below the surface, roughly speaking at about one-fifth of the actual depth, the current seems to have its maximum velocity, and consequently the hull of the vessel floating down the stream is immersed in water flowing more rapidly than that at the surface, on which the rudder for the most part acts.

I was enabled to demonstrate this fact by the following simple experiment. Having noticed that leaves of trees, after lying for some time on the ground and nearly saturated with water, become almost of the same, and after a longer time of greater, specific gravity than water, it occurred to me that such leaves, while in the first-named stage, would show what I desired to know, namely, the relative velocities of the stream at different levels below its surface. Two straight bars of wood, each about thirteen or fourteen feet long, were tied together at one end, between the two the foot-stalks of a number of poplar leaves were inserted (this kind was chosen because of the length of the footstalk for insertion between the bars, and its brightness of colour rendering it more visible in the depth of the water); the bars were charged with the leaves at intervals of about three inches, and then, choosing a place where the river was of suitable depth, the bars charged with leaves were plunged into the water, the connected ends touching the ground. The water was so clear that every leaf remained visible; then I opened the ends of the bars at the surface, and was gratified by seeing every leaf floating away and preserving as to depth very nearly the same relative position. Floating with the stream in my boat, I soon saw those nearest the bottom gradually lagging behind, and still more was I gratified when, after proceeding about forty yards, the leaves that were about two feet below the surface had distanced those at the surface in an unmistakable manner by at least three feet, the current being about four feet per second. The whole series forming a curve as is here shown.



Greatly pleased with this first experiment, I was not satisfied till I had repeated it again and again, not only on that occasion, but when the wind was blowing down the river, and therefore should have accelerated the leaf at the surface, which it undoubtedly did; but only the leaf on the surface, and that to a much smaller degree than I expected, and it left unaffected all that were beneath. A calm day is the best for this experiment, because the ripple renders it difficult to see below the surface. The water must of course be clear, a condition with which we are much favoured in this river. Mr. Maw's observations of the different velocities of the pieces of wood and the wave heads are quite in harmony with mine; the depth of the water in the stream at Merligen would be only a few inches, and pieces of wood were immersed so deeply that they would be more affected by the retarded current four-fifths below than by that one-fifth at the surface. J. P. G. SMITH

Sweyney Cliff, Coalport, Shropshire

Ocean Swells

THE late melancholy accident in Fingal's Cave, Staffa, by which three lives were lost, when several visitors to the island were washed off the railed ledge by a large wave which suddenly and unexpectedly broke into the cave, leads me to submit the following account of a somewhat similar wave and on the same part of the coast.

On the 4th inst. I took a small 5-ton sailing-boat from Oban to the Island of Lismore. We had a steady south-west breeze, going there with an even slight swell in the more open part, coming up the Firth of Lorne from the Atlantic. On our return the wind dropped to a dead calm and shifted to the south-eastward, so that to get back we took to the oars, the water becoming perfectly smooth as we neared Kerrera (between 5 and half-past 5 o'clock), when, standing at the bow, and looking seaward, I was surprised to see a broad wave or long swell coming from the south-westward, followed by two minor undulations. They

passed the boat, which rose and fell to them as they swept on. Ahead was the small island near the north-west entrance to Oban Harbour; Kerrera Island was close on the right or starboard bow. The sea was so calm, there was no sign of wash on either shore. As the wave rolled in I watched it, and after a few seconds the white line of surf became visible and the noise of the same following told of its breaking on the rocks with some violence. It was not the wash of any steamer, as the boatman at first unthinkingly surmised, for in the first place it was too broad a dome of water, many of our boat's lengths, into which the few short waves even of the largest steamers could not resolve themselves; secondly, there was no steamer in sight, nor had any lately gone by, save the Duke of Argyll's steam yacht, which had passed near us more than half an hour previously.

Such a wave could not have originated in the narrow channel between Mull and the mainland, but must have come in from the Atlantic, and had its origin, I imagine, in some far distant submarine disturbance. I have seen a report in the papers of an earthquake in Jersey, and I am informed by some friends lately returned from Cornwall (near St. Michael's Mount), that on August 26, about 4 p.m., when watching a seine net being pulled ashore, a wave larger than usual—described as a long black line, seen for a long time—rolled in. Perhaps others may have noted similar waves at other parts of the coast, and been able to record the exact time. H. H. GODWIN-AUSTEN

Deepdale, Reigate, September 9

Salmon-Breeding

ON August 28 an examination was made at Lord Lauderdale's fish-rearing ponds at Howietoun into the condition of the young salmon and hybrid Salmonidæ, and with the following interesting results:—

A hybrid was taken from Pond No. 3 which measured 6·5 inches in length; it was one of about 190, all much the same size, which were raised from the eggs of the Lochleven trout fertilised from the milt of the American char, *Salmo fontinalis*, on November 15, 1882. The specimen was a male with the milt nearly fully developed; the fish would evidently have bred this winter.

A hybrid was removed from Pond No. 4 which measured 7·5 inches in length; it was one of about 90, and raised from the ova of the American char milted from a Scotch char from Loch Rannock on November 15, 1882. It also was a male with the milt as fully developed as in the preceding hybrid.

Segregation in these ponds has been most rigidly carried out, and the results show that trout and char, or two species of char, will interbreed and give fertile offspring. A few more months will decide whether the females are as forward as the males, and whether the milt itself is prolific or not so; also to what extent hybrids will interbreed.

A hybrid was removed from the Octagon Pond at Craigend which measured 6·5 inches in length; it was one of 212, and raised from the ova of the Lochleven trout, fertilised by salmon milt on December 24, 1881. It was a barren female; whether any will be fertile time will show.

A grilse was taken from the salmon pond at Howietoun which measured fourteen inches in length; there are a large number, but they are in too deep water to count. These fish were raised from the ova and milt of pure salmon taken from the Teith in December, 1880. The specimen was a female, with the ova well advanced, being 0·1 inch in diameter, and would have bred this season. This fish was well nourished, with eleven rows of scales between the adipose dorsal and the lateral line, and sixty cæcal appendages. This solves the question that our salmon may not only be reared in a healthy state in suitable ponds of fresh water, but also, if properly cared for, will breed without descending to the sea. Last year the milt of the parrs from this pond were successfully used for breeding purposes.

FRANCIS DAY

Hydrodictyon in the Eastern Counties

IT may interest some of your readers to know that *Hydrodictyon utriculatum* (Roth), reckoned by Dillwyn among the rarest of the fresh-water Algæ, and now generally described as confined to the ditches and pools of the Midland and Southern Counties of England (W. J. Hooker, 1833; Harvey, 1841; Hassall, 1845; and Griffith's "Micrographical Dictionary," 1883), can again be claimed as an inhabitant of the *Eastern* Counties. A few days ago I found a fine and well-grown specimen in the river just above the well known sluice at Denver.

In the earlier half of the present century Cambridge seems to have been the centre for its distribution. Dillwyn, in 1809, relates that he received his specimen from the pool of the old Botanic Garden. Harvey, in 1841, says that he has fine specimens from Prof. Henslow, gathered in a pond in the Botanic Garden at Cambridge, where the plant has existed for many years. Hassall, in 1845, repeats Harvey's words, again on the authority of Prof. Henslow. Since that time it appears to have become completely extinct in this neighbourhood. The Curator tells me that two or three years back an attempt was made to introduce it into the pond of the new Botanic Garden, but without success. It is, I think, therefore worthy of record that this remarkable plant, so interesting to the biologist, has been lately discovered, apparently naturalised, at the bottom of the Ten Mile River, about twenty yards from the tidal waters of the Ouse.

The reappearance of Hydrodictyon on the fens round Cambridge is also interesting from the hope it inspires that, owing to the increased facilities for investigation now afforded by the University, further light may be thrown upon its singular cycle of development which, notwithstanding the labours of Areschoug, Cohn, Pringsheim, and others, must be said to be still somewhat obscure. J. C. SAUNDERS

Downing College, Cambridge, September 4

The Sky-Glows

THE sun-glow phenomena have entered upon such a fresh phase that I venture to send some extracts from my notes. It is not simply a renewal of the sunsets of last season, although that in itself will doubtless seem remarkable to those who have not noticed the almost constant occurrence of the "day glows" throughout the summer; the chief point is the radiating character.

September 11.—Glow 6.50 p.m. At 7 a vertical bar 2° to 3° across at base, to altitude 20°. Another at angle 45° to north; at 7.3 a third at angle 30° to north. The three faded at 7.5, 7.7, and 7.10.

September 12.—Sun seen to set by 6.20. At 6.35 ruddy tint above earth shadow in east; gone at 6.45. 6.50, fine glow from north-west to south-west, up to 30°; 6.55, very fine, up to 35°; much purple. Gradual change to low orange glow by 7.4, this fading by degrees, but partial return at 7.9; little left at 7.19.

September 13 (*sunrise*).—4.57 a.m., lovely orange glow and reflection in west. Cirri bright. 5.0, pink shot up vertically (in inverted pyramid) to height of Jupiter. 5.0½, bar at angle of 45° to north. 5.5, whole north-east to south east suffused, broken by dark bars, four to north, five to south, radiating from sun. Central mass now 5° to 10° above Jupiter. Cirri now dark at east, but slight tint near Venus (these proved to be higher and more feathery, the others about 7° or 8° above east by north, approaching to cirro-strati). 5.7, now five bars to north, seven to south. Light wider spread, now to level of Venus (roughly measured as 35°). Soon traces even to 45°. Bars *very* marked; one from east-north-east reaches north-north-east, at altitude about 22°. Low cirri now re-lit. 5.15, whole mass now barred; nine to north, and two new ones to south of centre, but lower part to south now gone. Cloud over Venus now re-lit. 5.20, going to west window find marked *counter-glow*, also barred, radiating from perspective just like bands of cirrus, yet marvellously clear sky. Four dark bands to south, five to north, wider than those seen in east, and definition much less distinct. Rosy tints now gone. A ruddy tinge almost from south to north above earth-shadow, *except just south of due west*, whence rose a broad dark vertical bar. Faint cirri to south now lit up. 5.28, bars to north and south still visible, and no glow above earth-shadow at anti-solar point. Glow lasting at 5.30. Cirri in east quite dark again, but the cirri near Venus and to south white. Former now in vertical lines, but upper edges blown in wisps towards north. 5.40, stratus low in east by south. A greenish cast given to Venus and Jupiter when the glow strongest. Rosy glow at times noticed during the day. Sun rose about 5.50.

Sun set before 6.20.—6.35, ruddy tinge along east horizon, keeping above earth-shadow as it ascends. 6.45½, cirro-stratus 5° to 10° above horizon, due west again lit up bright (first at 6.30) for two or three minutes, quickly followed by rosy glow in clear sky, as three central bands, divided by narrow dark bars,

and corresponding to the single mass on the 11th. 6.53, seven bands to south, a fine trio at an angle of 45°, five to north, much less distinct. No sign now of counter-glow. 6.55, orange next horizon; bars to south as bright as the vertical mass. 6.58, all fading; at no time reached beyond 25° altitude. 7.1, only the bases left of five bars to south, three vertical, and three to north. Positions show well the place of the sun below the horizon. 7.3, rose tints quite gone; none of last night's purple at all. 7.6, the cirro-stratus again tinged at edges. 7.9, as orange fades, last vestige of bars goes; stratus forming; the cirro-stratus still lit up. Sky very clear for York; none of the hazy clouds which accompanied the glows last season. 7.15, still red tinge along horizon.

September 14, *morning*, 5.7.—Find sky bright on waking; rose above, orange to greenish, yellow below; orange most marked, but rose wider spread, involving Venus, which, with Jupiter and moon, showed complementary effect. Only one dark bar, low down to north. Coloured area increased up to 5.15; fairly bright at 5.20; perceptible at 5.25. *Counter-glow* very marked at 5.20, massed above earth-shadow at anti-solar point, just where, yesterday, there was no ruddy tinge. *No* cirri about, only light scud low down to east, from north to south. Very clear.

This evening (14th) scud covered the sky a little before 7, and, so far as I know, nothing special was observable. Is it possible that the bars were due to shadows thrown by cirri below the horizon? J. EDMUND CLARK

Bootham, York, September 14

THE following observations of the warm, yellow circle about the sun, unusual colours of sky and cloud, &c., may interest some of your readers just now. The beautiful, warm, yellow solar halo, silvery white within, was seen on the following dates, usually a little before, during, or after sunset:—May 18, 19, 24; June 11, 25, 26, 27; August 14, 19, 24, 27, 29; September 1, 3, 4, 5. On two occasions, in cloudless sky, the halo was visible from noon to sunset. Unusual and beautiful colours were seen near the sun on August 24, at 3 p.m., September 1, 3, and 5. These colours were first noticed at 2 p.m., November 26, 1883. The extraordinary sunsets began here in November 1883; the dates are as follows:—

1883.—November 6, 14, 25, 28; December 1, 3, 4, 5, 11, 15, 16, 17, 18, 19, 22.

1884.—January 5, 11, 15; February 15, 24.

The colours at sunrise were very fine on November 4, 29, and December 4, 9, 19, 1883; January 12 and February 9, 1884.

J. GLEDHILL

Mr. Edward Crossley's Observatory, Bermerside, Halifax, September 10

EVEN last evening the glow was very marked. At 5.6 a belt of orange-colour lay on the horizon near the point of sunset, having a breadth of 4°. From this base shot up the bluish-white cone, while on each side (south-west and north-west and skirting the horizon) the sky had a smoky-brown aspect. The whole was overtopped by an arch of a pale smoky-pink hue, the outer circumference of which reached an altitude of about 30° as measured from the horizon. At 5.8 the bluish-white cone had become more intense, and the eastern sky was of a pale green. At 5.12 the bluish-white cone, with brown sides and orange base, was very distinct. At 5.14 I noted a long ellipse of intensely blue sky, the meridian forming its major diameter. On each side, west and east, were areas of bluish-white, the latter apparently being a reflection of the former, and having a base on the eastern horizon of dull greenish-brown. At 5.21 I examined the sunset sky with the spectroscope. The low sun-band was becoming dark; the merest possible vapour shading appeared, detached, to the left of D, the little "*c*" lines were clear, and B (dry gas) intense. At 5.31 the low sun-band had become much deeper. By 5.38 a secondary glow had appeared: pale lemon extended for some 7°, overtopped for the next 20° by an intense smoky-pink, the opposite sky being a dull green, while that immediately above the horizon south-west and north was brown, and the landscape was tinted with a warm glow. The little "*a*" band was now intense, so also was the low sun-band, and all trace of vapour effects to the left of D had vanished. At 5.43 the glow was "settling down" and had a total extension of some 14°, 7° of orange and 7° of green. The whole thing finished off with a belt of pale sea-green about 10° in diameter shortly after 6 o'clock.

I have taken a great number of observations *in re* since my arrival in Australia last December, and am now collating them in accordance with the request of the Editor of NATURE (vol. xxix. p. 157). In a word, I am at present strongly in favour of the volcanic hypothesis, and claim to have sufficiently shown in a paper recently delivered before the Royal Society of South Australia that the relatively high pressure prevailing *over* the low pressure of Southern Asia at the time of the eruption prevented the dust from reaching India, so as to produce the effects of the "glow," until the lapse of a fortnight, and that the dust travelled westwards and southwards aided by the rapid equatorial rotation of the earth and the vertical distribution of pressure in oceanic regions south of the Line.

CLEMENT L. WRAGGE

Torrens Observatory, near Adelaide, July 31

P.S.—I have repeatedly observed the "glow" in broad daylight, and it is now (*noon*) visible as a bluish-white glare.—C. L. W.

LAST year, when staying at this place, I was much struck by the clearness of the air, the deep blue of the sky, and steadiness of the stars. Moreover I used to notice on every clear day that the highest cirri, when near the sun, exhibited very beautiful spectrum colours. They did not behave as I have seen them behave once or twice in England, viz. take up all the colours in regular succession as their angular distance from the sun altered; but each cloud exhibited the colours in an apparently irregular manner that reminded one of the appearance of mother-of-pearl. This year it seems to me that the air is of a less deep blue, and on every clear day there has been a very marked reddish glow all round the sun. This red glow in the midst of what would otherwise be a pure blue sky has been very noticeable. It has nearly, though not quite, "swamped" the diffraction colours spoken of as so remarkable last year. W. LARDEN

Avolla, Sion, Canton Valais, Switzerland (about 6500 feet)

Pipe-Clay

I WAS forcibly struck the other day by the analogy between the beds of plastic clay (called here pipe-clay) which are everywhere met with interstratified with the different drifts of wash-dirt, river-sand, &c., in the tin-mines about this country, and what was then to be seen in our own mine here. The mine had been under water for about a month. On pumping the water out, we discovered a layer of particularly fine, soft mud, four inches in depth, of about the consistency of cream. It is evident that any animal or vegetable substance dropping into this layer would sink through it and rest on the bottom. The pipe-clay contains no fossils except portions of trees which rest on the bed beneath it. Now, from the evidence before me here, I am led to the conclusion that the beds of pipe-clay were formed under like circumstances as these. The old torrents which brought the drift down from the mountains were undoubtedly continually changing their paths as they traversed the valleys, being dammed by accumulations of timber and boulders, thus causing the diversified and mixed-up appearance of the beds, some of them containing huge trees and heavy stones: these are the beds which contain the richest deposits of tin ores, others being beds of fine quartz sand, with beds of materials graduated between the two descriptions, and the beds of pipe-clay interspersed. These last vary considerably in depth. I have seen them all thicknesses between one inch and twenty feet.

The beds containing heavy materials were undoubtedly brought down by tremendous torrents caused by heavy rain-falls; the lighter materials by the shrunken torrents during dry seasons, or from a diversion of the course of the main stream. If this is the case—and it seems to me most probable—I think that it is a fair deduction to say that the pipe-clay was deposited in ponds left by the decreasing torrents in their periodically-used channels, which ponds would probably be perfectly still water, and favourable for such a deposit, in the same way as this mine was in a position favourable for the deposit of four inches of slimy mud in a month. I am at a loss to account for the fact that these beds (of finer materials) do not contain any animal remains. The heavy beds contain very much heavy timber, but of course all smaller and more delicate animal or vegetable remains would be smashed up here: this does not, however, apply to the other beds, if my theory is correct, and yet no

fossils are to be found here, nor can I hear of any having been found elsewhere.

With reference to the suggestion of the Rev. J. E. Tenison-Woods (NATURE, May 22, p. 76), that the tin is probably derived from below the gneissose formation and above the granite, this seems to me a most probable conclusion, although I have seen no more of the clay-slate than water-worn blocks mixed with the blocks of quartzose granite in this mine; but I do not feel quite certain that the so called laterite is derived from this clay-slate formation, as it contains very much quartz sand, and, so far as I have seen here, nothing that resembles a sand resultant from the decomposition of the clay-slate.

I was over in Kintah the other day, and heard of a hot spring at a village called Samban, near Ipoh; there are, I believe, several others about in the peninsula, and I understand that sulphuric acid is emitted from the bottom of some of the mines at Lahot, especially M. De la Croix'. These are the only signs of volcanic action since the granite that I have heard of or seen.

In conclusion I cannot help indorsing the Rev. Tenison-Woods' opinion that there are great quantities of tin here only waiting to be worked. A. HALE

Ulu Bakow, Perak River, July 25

Repulsion

SIR W. THOMSON, in his address at Montreal, asks: "May it not be that there is no such thing as repulsion, and that it is solely by inertia that what seems to be repulsion is produced?" And he proceeds to illustrate this by the case of two mutually attracting bodies approaching, then dashing past one another in sharply concave curves round their common centre of gravity, and so flying asunder again. He adds that this idea was suggested to him thirty-five years ago by an observation of Sir H. Davy. And I think one may gather that his impression is that it is one that has not presented itself to other minds in the interval.

I cannot but think that such an idea must have been "in the air," among mathematicians, from the time when first any similarity was thought of between the action of molecules and masses. At any rate, I certainly never read Davy at first hand, and yet, in 1874, I published an "Elementary Exposition of the Doctrine of Energy," intended for schools (which I fear fell dead from the press), and in a section on "Molecular Theories" I wrote as follows:—

"Two bodies subject only to their mutual attraction, if their motions at any one moment are not in the same straight line will never come in contact. . . . The orbit may be like a comet's, very nearly a straight line in the greater part of it, turning sharp round at each extremity, . . . at the nearest with enormous impetus. This shows that what we call elasticity in a mass *may*, wholly or in part [this was meant to exclude the case of *direct* collision, as to which Sir W. Thomson also enters a *caveat*], be the result of *attractive* force combined with motion. A blow given on the surface of the solid mass drives the particles inwards; but the result may be a pirouette round some of their inner neighbours, and an equally strong outward impetus driving back the hammer with an energy proportionate to that which it had given."

My intention in that section was to excite thought in school teachers and apprehensive and energetic scholars; but I did not imagine I was starting a novelty. He who propounds a working hypothesis of molecular action in which this idea plays a part will have the whole credit. D. D. HEATH

Kitlands, Dorking

Fellow-Feeling in House-Flies and Swallows

THE moral feelings of animals being as interesting as their intelligence, perhaps the readers of NATURE would care to hear of a curious instance that I just now witnessed of fellow-feeling in the common house-fly. A number of them had collected in the top of a window, and I was about to open it to let them out, when I saw a wasp seize one, as I have seen many seized this year, but never before, though I have often seen them feed greedily on maimed *bees*. The wasp was about to sever the head from the body of his victim, when a fly—by no means a large one—flung itself violently against the captured one, trying apparently to knock it away from the wasp; it did not attack the wasp. This was done again and again, whether by the same fly or another I could not tell, the action was so rapid; at last the body of the fly was knocked away, but the wasp retained the head and devoured it. It then grasped another, and again a fly dashed at it, and another, and another, though they were all evidently afraid of the wasp; and no wonder; it seemed very fierce and hungry. The action of the flies was quite unmistakable. I called another person to watch it with me, and she was as much surprised as I was, and inclined to kill the wasp; but I thought we could spare a few flies, notwithstanding this unexpected discovery of fine feeling in them, and I would not let her disturb the balance of Nature.

I was once a delighted witness of a still more curious instance of fellow-feeling in some young swallows. Six of them were sitting on a low roof, and were being fed by the old bird, who flew by from time to time, and put something into one or two of the open beaks. Each time, as soon as they saw the parent coming, which was some time before I did, they all stood up, whirring their wings and chattering; all, that is, except the last but one, and that seemed to be weak and unable to rise, and so got nothing. At last the two that flanked it, after a great deal of chattering over it, managed to raise it up by putting their beaks under its little white bosom; and then and there the dear little brotherly things wedged it up between them with the prettiest air of compassion and patronage, so that it had a fair chance with the others. And it seemed quite a chance which was fed, yet all sat down apparently perfectly contented and good-humoured afterwards. It was a pretty sight, and I was grieved when, some boys coming by, they took to flight.

Sidmouth, September 13 J. M. H.

Rainbow on Spray

THE appearance noticed by "G. H." in last week's NATURE (p. 464) is a well-known sight at sea under certain conditions. I first saw it from the deck of the Anchor Line s.s. *Bolivia*, about two hundred miles east of Cape Cod. It lasted for half an hour between 10 and 11 a.m. The sea was going down after heavy weather: the sun was shining brightly in a clear blue sky, with light, fleecy clouds scudding along. A fresh westerly breeze cut the tops off the rollers and cast the spray high in the air. When the procession of waves passed through an area more or less opposite to the sun, their crests took up beautiful rainbows; there were thousands of them, and as the steamer rolled and pitched, the changing angle caused the spray on some waves to take more of one or other primary colour, seeming now blue, now red, and again yellow golden.

Leeds, September 13 FRANK E. CANE

JAPANESE EDUCATION

THE Japanese Government, having decided to take a more prominent part in the Health Exhibition than they did last year in the Fisheries—due, we believe, in the latter instance to the fact that they had a Fisheries Exhibition of their own in Tokio at the same time—have appointed a Commission to superintend the Japanese Section, among the members of which is Mr. S. Tegima, the Curator of the Tokio Educational Museum, who has been specially appointed to superintend the Educational Section. To accompany the exhibits in this Section the Government have published a little hand-book, which has been reproduced in the *China Telegraph*, and which contains the most exhaustive account of modern Japanese education, its system, and results, that we have seen in any European language. The Annual Report of the Minister of Education is little more than a mass of statistics; the number of children attending primary, secondary, &c., schools for some years past is carefully given, but we are left to guess at the subjects taught and the course of instruction in these establishments. We are not grumbling at the Report on this ground; it is what it professes to be; we merely desire to point out the special interest of the present little work. The Japanese can look back with pride on a large—a very large—portion of the national work of the past fifteen years; and in education, whatever it may have been in other departments, there has never been the slightest faltering or doubt as to the wisdom of extending the benefits of an improved system to every village and hamlet in the Em-

pire. And perhaps the statesmen who have steadily pursued their policy in this respect when the cry for economy, even at the expense of efficiency, was rising round them, have their reward even now. A Minister of State who recently visited Europe, talking to an English friend of the future of his country, stated that in Japan they trusted to their system of popular education acting on the intelligence of their people to prevent the spread of revolutionary doctrines; the schoolmaster was abroad in the land, and its rulers could rest safe from that danger at least.

The Education Department in Japan is one of the ten principal offices of State, its head ranking as a first-class Minister. It has the usual staff of Vice-Ministers and Secretaries, who carry on the business, and from time to time visit and inspect the various districts. All the local governors are, in educational matters, directly under the control of the Minister. The salaries of professors range from about 1000*l.* per annum (foreigners probably) to 250*l.*, and those of teachers from 100*l.* to 30*l.* The latter are, we believe, considerably higher in proportion than those of Board-school teachers in this country. School text-books are chosen with great care, and by the Department itself; indeed almost all the books are compiled and published by the Government. In the capital two establishments have been organised in the interest of education—one a library where works in all languages are collected, and placed, under certain slight restrictions, at the disposal of the public; the other the educational museum, in which objects necessary to general education are collected for the benefit of those engaged in it. The rules by which all schools are governed, whether they are local, general, or private, appear ultimately to come under the notice of the Minister of Education for his approval, so that the administration is a highly centralised one. An important feature of the work is the number of students sent abroad by one or other of the Departments of State. The Education Department has sent fifty in the past seven years, and there are at present twenty-two abroad, of whom seventeen are in Germany, one in Austria, two in England, one in France, and one in America. All these are graduates of the Tokio University, who were specially selected by the Minister of Education for the purpose of being sent abroad. The great preponderance of these in Germany is remarkable, and would appear to show that the Japanese are inclined to discard English and American educational institutions (which have had their day in Japanese estimation) for those of Germany. On the other hand, it may be that those are mostly medical students, who have from the beginning been sent to German Universities. Before coming to the various classes of schools, the statistics had perhaps better be given. The following are for 1882, the details for 1883 not being yet forthcoming:—

	Number	Professors and Teachers	Pupils
Elementary schools	28,908	76,769	2,616,879
High schools	173	934	12,315
Normal schools	71	602	5,275
Universities	2	135	2,035
Technical schools	98	975	8,829
Other schools	1,026	2,598	72,260

Of the 2,616,879 pupils at the elementary schools, only 733,691 are girls. Nearly the whole of these schools are maintained by the various local Governments, *i.e.* out of local, not Imperial, taxes. The whole system is administered under a code first promulgated in 1872, re-issued in an improved shape in 1879, and again revised in 1881.

The lowest schools of all are the Kindergarten, where children under school age are taught for three years reading, writing, ciphering, embroidery, paper-plaiting, drawing, &c. The next grade is the elementary schools, where a general education is given, and at which attendance is compulsory. The district for such a school varies with the population and resources; but theoretically, and as a rule in practice, one exists in every ward and in every village. The course of these schools is divided into lower, intermediate, and higher grades. The lower grade course comprises the elements of morals, reading, writing, arithmetic, singing, and gymnastics; the intermediate, besides these, includes geography, history, drawing, physics, and natural history; while the higher grade adds chemistry, geometry, physiology, and political economy. Teachers receive certificates either for a certain class of schools or for a special subject from the normal schools, or from the local inspectorates. Committees or Boards, similar apparently to our School-Boards, are formed in each district, but their functions are limited to seeing to the attendance of the children, and they seem to have no power over the finances of the school. The next grade of schools is the "middle schools," organised in each district according to the local conditions and demands. Their object is to give higher instruction in the ordinary branches of study, so as to prepare students for liberal pursuits or for the more advanced schools. In addition to the subjects already specified, we find the middle-school course including elementary mathematics, natural science, geology, Japanese law, and one European language. To provide a model for these schools, the Minister of Education established a middle school at Osaka, to which reference can be made. There is only one University, that of Tokio, with four departments, law, science, literature, and medicine. Nothing need be said of this, as it is organised in the usual way. There are two preparatory schools for it, and the department of science appears to be well equipped with astronomical and meteorological observatories, botanical gardens, and museums.

In addition to these, which may be called the ordinary educational institutions, there are special colleges attached, or under the control of certain Departments. Such are the Military Academy, the Engineering College, the Training Schools for the Navy and Army, the School of Marine Engineering, of Forestry, Law, Telegraphy, &c. The normal schools for the training of teachers should also be noticed. They are established in almost every district, and now number seventy-six. The Government has provided two model normal schools in Tokio, one for male teachers, the other for females, and it is worth noticing that the latter was opened by the Empress herself. There are two schools of agriculture, one near Tokio, the other at Sapporo in Yezo. In the former the students are instructed in the science of agriculture, in veterinary science and agricultural chemistry, while in the latter stock-rearing and cultivation are taught.

These appear to be the chief features of the Report, and it is much to be wished that the compilers had given some information regarding the part played by Europeans in Japanese education. A comparative statement of the number of Europeans employed in the Department or in local schools eight or ten years ago, and now how far the posts they occupied have been abolished, or occupied by Japanese found suitable for the work, would have been interesting.

BRITISH BIRDS AT THE NATURAL HISTORY MUSEUM

VISITORS to the new Natural History Museum can scarcely have failed to notice the many improvements which have been made in the re-arrangement of the zoological collections since their removal from Bloomsbury to South Kensington. Not only is there greater space now available for exhibiting the contents of each gallery, but a large proportion of new specimens have been introduced into the cases.

It is of course not to be expected that stuffed animals, however well preserved, will last for ever, and some of the

specimens in the national collection are considerably more than a hundred years old. A certain amount of "weeding out" from time to time is consequently unavoidable, and is by no means so easy a process as might be supposed. The preservation of "types," that is, of the original specimens from which the species were first described, has very properly been considered of great importance; they have been withdrawn from exhibition and exposure to light, and relegated to the study series; but old and badly-mounted specimens of no historical value have been discarded, and their places filled with recently-obtained fresh examples of the same species, preserved and mounted with all the skill which modern taxidermists have been able to bestow upon them.

The Osteological, Cetacean, and Coral Galleries contain collections which were but incompletely represented in the exhibition rooms of the old building, and in fact, offer to the visitor entirely new exhibitions, of which those who have been engaged in their formation and arrangement may well be proud. None of these, however, appeal by their direct instructiveness to the British public, or are appreciated by them so much as the series of groups of British birds illustrating their mode of nidification, which is placed on the right and left of the central hall.

Here the visitor finds a collection of British birds, in which each species is separately represented by a pair of old birds in the plumage peculiar to the breeding season, with its nest and eggs, not merely in a natural position, but in the actual position in which they were found; the arboreal birds being placed on the identical branches which they themselves selected for nidification, the ground breeders remaining on the actual patch of ground, whether grass-grown or heather-clad, in which they had designed to rear their young.

It is needless to enlarge upon the advantage to be derived from a lesson thus accurately imparted, or upon the excellent opportunity thus afforded for comparing the variation in structure of nests built by birds belonging to different orders and families. As an aid, also, to the identification of the owner of a nest unknown to the finder, the series is a useful one, and will become more so as the collection is extended, for the process of forming and preparing such a collection must be slow. It is nearly four years ago since Dr. Günther commenced its formation, and without the aid of ardent lovers of nature like Lord Lovat, Mr. T. Harcourt Powell, Mr. D. Parker, Colonel Irby, and especially Lord Walsingham, it would have been impossible for him to have made this series, as it is, one of the most instructive attractions of the Natural History Museum. As for ornithologists, it is difficult to say where the interest ceases.

Not very long since Mr. H. Seebohm gave a lecture at the Zoological Gardens on "Birds' Nests," and could he have pointed to these beautifully-mounted cases at South Kensington, he would have had the most appropriate illustrations possible to his discourse.

From an attentive study of the subject he considered that nests might be roughly grouped into five classes, according as the birds which owned them relied for the safety of their eggs: (1) on the concealed position of the nest; (2) upon the inaccessible position of the nest; (3) upon the protective colour of the eggs; (4) upon the protective colour of the sitting hen; (5) upon their own ability, either singly, in pairs, or in colonies to defend their eggs.

Illustrations of all these five classes (and Mr. Seebohm might have added a sixth, viz. contrivances employed for concealing the eggs on the bird leaving its nest) may be seen in the British Museum cases, and furnish as good a basis as any for studying the series.

Starting from the entrance to the Mammalia Gallery, and proceeding towards the staircase, we at once come upon several cases of birds which rely for the safety of their eggs upon the concealed position of the nest. Here we find a pair of dippers with their nest of green moss most skilfully constructed and domed, placed just under a moss-grown stump overhanging the water. Patches of the same moss around and about the stump deceive the eye and render detection of the nest very difficult, unless the bird is seen to leave or enter it. A section of the nest, represented by an illustration, shows a curious feature in its construction. It is not only cup-shaped and domed, but the front edge of the cup curls over towards the centre of the nest, as if to protect the pure white eggs from any drip or spray from the stream in whose banks the nest is placed.

Close to this group we find two cases of woodpeckers, the green woodpecker or "yaffle" and the greater spotted woodpecker, both of which deposit their white eggs in the hole of a tree, the aperture of which as a rule is only just large enough to admit the bird, and consequently the nest, composed of dry chips and bits of bark, is well concealed But the woodpeckers might, with almost equal propriety, be placed amongst those birds which rely for the safety of their eggs on the inaccessible position of their nest.

It has been stated that as a general rule all eggs which are deposited in holes or in well-roofed nests are white, and certainly we have illustrations of this in the case of the dipper, woodpecker, owl, kingfisher, swift, sandmartin, and other birds; but, on the other hand, the jackdaw, nuthatch, tree-creeper, and various kinds of titmouse, all breed in holes and yet lay coloured eggs; while the pigeons, doves, grebes, and waterfowl lay white eggs in open nests; so that no precise rule can be laid down on this head.

Almost all the small passerine birds may be said to rely for the safety of their eggs on the concealed position of the nest; hence it is difficult to name any without giving a long list of names. In the Natural History Museum series the following examples may be noted:—The yellowhammer, with its nest of dry grass placed in a clump of dead furze, whereby a contrast of colour is avoided which might lead to the detection of the nest; the meadow pipit, with its nest concealed in meadow grass; the reed bunting, with its nest placed low down, to escape observation, in a clump of rushes. Were this nest placed higher up in a plant of such open growth, it would be sure to attract attention. In like manner the linnet and Dartford warbler in furze, the skylark, yellow wagtail, and whinchat in meadow grass, all furnish illustrations of variety in the art of concealment as practised by the tiny architects.

Amongst birds which rely for safety on the inaccessible position of their nest may be mentioned the hawks and owls, raven, chough, kingfisher, sandmartin, moorhen, coot, and grebe. There are few eggs more difficult to take than those of the peregrine falcon, raven, and chough, from the habit of these birds to nest in precipitous cliffs; the kingfisher and sandmartin, breeding in holes which sometimes extend several feet into a bank, and often not in a direct line, evidently imagine themselves safe from molestation; while moorhens, coots, and grebes, making slovenly-constructed nests upon soft, treacherous ground, or amongst sedges, flags, and other water plants which are unapproachable without the aid of a boat, afford another instance of how the same object may be achieved by a different method. One cannot fail to note that the more slovenly the nest of these water-birds the more likely is it to escape detection, for, were it well shaped and neat in appearance, its very neatness amidst a mass of wind-strewn rushes or tangled growth of water-weeds would be sure to attract attention towards it.

To give instances of birds which rely for safety on the protective colour of their eggs, we might mention the nightjar, peewit, stonecurlew, snipe, woodcock, ringed

plover, oystercatcher, the various species of tern or sea-swallow, and, generally speaking, all those birds which habitually deposit their eggs upon the ground, with little or no vestige of a nest.

Only those who have sought for and found the eggs of the peewit, stonecurlew, ringed plover, and oyster-catcher can have any true idea of the remarkable approximation in the colour of the eggs to the ground whereon they are laid, the two first-named resembling the small clods and stones upon the fallows where they are found, the two last-named counterfeiting the freckled, water-worn pebbles of the beach.

Many of the above-named species and others are already represented in the Museum series. The group of the ring plover with the newly-hatched young hiding between, and scarcely distinguishable from the pebbles, is charming by its simplicity; whilst the bit of Scotch moor with the woodcock's nest will arrest the attention of every sportsman whose personal experience of this bird has been limited to a glimpse of it in the shooting season.

If we look around the collection for instances of species which rely for the safety of their eggs on the protective colour of the sitting hen, we shall find excellent illustrations in the case of the pheasant and grouse, two of the most life-like groups in the series. In the former

Grebe and Nest

case we seem to have a little bit carved out, as it were, and carried away from an English wood in spring-time—primroses, bluebells, and all!

It is probable that in this same class we must include all the game birds, a large number of the passerine birds (excepting those in which, as in the tits, wagtails, pipits, larks, and some of the warblers, the sexes are alike in plumage), the woodcocks, snipe, and ducks. But of these, as will appear from our previous remarks, the passerine birds would as well rely for safety on the concealed position of the nest, and the woodcock and snipe, on the protective colour of their eggs.

In a notable essay entitled "A Theory of Birds' Nests," published some years ago, Mr. A. R. Wallace, amongst other ingenious propositions, attempted to establish the rule that, in all cases where the hen bird is brightly coloured like the male (as in the kingfishers, woodpeckers, tits, &c.) nidification takes place either in a hole or in a roofed nest; while in cases where the sexes differ in plumage, and the hen bird is of a dull colour (as in the pheasants, for example), the nest is open and the sitting bird exposed to view.

This theory, though at first sight plausible, is really untenable; for the exceptions which may be brought forward in both classes are as numerous as the cases cited in support of it. On reflection it is apparent that jays, orioles, and pigeons (many tropical species of which are brilliantly coloured), according to Mr. Wallace, ought to

be found breeding in holes or in roofed nests, their eggs concealed from view; but, on the contrary, they build open nests, some of them, as with the pigeons, being very clumsy and conspicuous structures. On the other hand, birds like the creeper, nuthatch, wren, willow wren, and chiffchaff, with the hen birds of sombre colours, would be expected, on Mr. Wallace's theory, to build open cup-shaped nests wherein the sitting bird would be exposed to view; but the two first-named breed in holes of trees, and the others all construct domed nests. It would be easy to take exception to other propositions made by Mr. Wallace, and generally to combat his ingenious theory; but such is not our object here. We have referred to his essay rather for the purpose of redirecting attention to it in connection with the admirable series of birds' nests in the collection under notice which furnishes the reader with illustrations to many of Mr. Wallace's remarks.

As to the birds which rely for the safety of their eggs on their own ability to defend them, whether singly or in pairs or colonies, familar examples occur to us in the partridge, peewit, and black-headed gull. There must be few observant naturalists who have walked abroad in the nesting time and have not witnessed and admired the extraordinary efforts made by some or all of these birds to decoy the intruder away from their eggs or young by feigning lameness, or to frighten him away from the spot by boldly dashing at his head with loud reiterated cries.

The group, of which an engraving is here given from a careful sketch by Mr. Charles Whymper, represents a pair of little grebes, or dabchicks as they are provincially called, at a pond-side, with their characteristic nest of weeds. The hen bird is just leaving the nest to join her mate, having hastily covered her white eggs to conceal them.

The taxidermist, it will be observed, in this case has been obliged to show them partially uncovered, in order to explain what otherwise might remain unsuspected by those who are unfamiliar with the habits of these interesting birds.

NOTES

THE Queen has been pleased to confer the dignity of a Knight of the United Kingdom on John William Dawson, LL.D., C.M.G., Principal and Vice-Chancellor of the McGill University, Montreal, in the Dominion of Canada.

THE death is announced of Dr. J. J. Woodward, surgeon, United States Army, the well-known microscopist, whose admirable photo-micrographs, produced during his official connection with the Army Medical Museum, Washington, have given the pre-eminence to America for this branch of scientific microscopy.

THE Electrical Conference at Philadelphia has adopted resolutions that steps should be taken to legalise in America the ohm adopted by the Paris Conference, as also the ampere and volt, as electrical standards of measure. It was proposed by Mr. W. H. Preece that the Committee should consider the adoption of the English watt as a unit of power; this was also adopted.

PROF. ROBERT S. BALL lectured in Philadelphia on Wednesday night last week on the distances of the stars. He had a large audience at the Academy of Music.

THE first aërial voyage in England having taken place from the Honourable Artillery Company's ground at Finsbury on September 15, 1784, in the presence of the Prince of Wales, afterwards George IV., preparations were made to fittingly celebrate the 100th anniversary of the event, which occurred on Monday. A committee successfully perfected the arrangements for the ascent of three huge balloons from the grounds at the rear of the Finsbury Armoury, whence, at 5 minutes after 2 in the afternoon, just a century before, Lunardi, the secretary to the Neapolitan Ambassador in London, started upon the first aërial voyage performed in this country, and ultimately descended, at 20 minutes past 4, in safety in a meadow at Standon, near Ware, Hertfordshire. In the Long Room, Col. Beaumont, R.E., presiding, M. W. de Fonvielle, editor of *La Lumière Électrique*, delivered an address, in which he described the improvements made in the construction and the gear of balloons during the past century, particularly alluding to the improvements effected by the late Mr. Green, the inventor of the cone anchor, which had been the means of saving the lives of so many aëronauts when they drifted out to sea, and had been rescued by passing vessels. He spoke hopefully and sanguinely of the ultimate success of the efforts now being made by gallant French officers to steer balloons by the medium of electric currents.

A SECOND ascent was made on Friday at Meudon in Capt. Renard's new balloon, but this time without the success which attended the former experiment. There was a good breeze. On the previous occasion, it will be remembered, there was only a slight breeze. After resisting the wind and remaining stationary, or nearly so, for a few minutes, the balloon was carried in the direction of Versailles, and, on one of the batteries ceasing to work, descended near Versailles. From there the balloon had to be dragged back to Meudon. The inventors assert that, but for the accident to the battery, they would have returned to Meudon in the teeth of the wind.

M. REGNARD has made a series of experiments on living organisms under high pressures. Yeast was found to be latent after having been subjected to a pressure of 1000 atmospheres for one hour; an hour later it began to ferment in sweetened water. Starch was transformed to sugar by saliva at 1000 atmospheres. At 600 atmospheres Algæ were able to decompose carbonic acid in sunlight, but they died and began to putrefy after four days. Cress-seed after ten minutes' exposure to 1000 atmospheres were swollen with water, and after a week began to sprout. At 600 atmospheres Infusoria and mollusks, &c., were rendered morbid and latent, but when removed returned to their natural state. Fishes without bladders can stand 100 atmospheres, at 200 they seem asleep, at 300 they die, and at 400 they die and remain rigid even whilst putrefying.

WE observe that among the three recipients of the gold medals awarded by the University of Christiania is Prof. G. A. Guldberg.

A NEW enemy to the beetroot plantations has appeared in Scania (Sweden) in the shape of the spinach-fly (*Anthomyza spinaciæ*). It has previously been known as an enemy to spinach, but this year it has also attacked the beetroot plants. Dr. Holmgren believes that its appearance is only periodical.

ALTHOUGH a great deal has been done in Norway and Switzerland to examine and measure the glaciers in those countries, comparatively little has been done in Sweden in this respect. During the last couple of years, however, a glacialist, Dr. F. Svenonius, has been engaged in studying and measuring some of the glaciers in Norrland, and we now learn from the report of this gentleman that there are about a hundred glaciers in Sweden, but that they are very small, the whole covering altogether only nine square miles (Swedish). The area had previously been estimated at thirty square miles.

THE Corporation of Southampton have unanimously resolved to support the movement commenced by the Council of the Hartley Institution a short time ago, in favour of a revised Geological Survey of Hampshire and the Isle of Wight on the maps of the 6-inch scale. The Southampton Town Council will

now invite the Corporations of all the other Hampshire boroughs to join them in the application shortly to be made to the Government on this subject. A large number of landowners and many of the Members of Parliament and Peers connected with the county have already expressed their interest in this matter.

IT is stated that Mr. Gamel of Copenhagen has offered to send his steamship the *Dijmphna* on a second expedition to the Arctic regions *viâ* Franz Josef Land, subject to the condition that the Danish Government will, as a moral acknowledgment of their interest in the Expedition, grant a certain sum of money, however small, towards the Expedition, under Lieut. Hovgaard of the Royal Danish Navy.

THE present number of the *Proceedings* of the Natural History Society of Newport (R.I.) contains several papers on the geology of Rhode Island, and one on its birds. There are, in addition, papers on Mount Tacoma in Washington Territory, by Mr. Bailey Willis; on the migration of birds, by Mr. Taylor; and an account of a journey in North-Western Wyoming, by Mr. Wilson. Several of these papers are accompanied by maps or other illustrations; but unfortunately in most cases only abstracts of the papers are given, while in others we get only the titles.

"CONTRIBUTIONS to the Descriptive and Systematic Coleopterology of North America," Part i., is the title of a paper of 60 pages with one plate of details, by Thos. L. Casey, Lieutenant of Engineers, U.S.A. In it are described about sixty new species and some new genera. Lieut. Casey is, we think, a *débutant* in North American systematic entomology, which sustained so severe a loss lately in the death of Le Conte; his descriptions appear to be carefully and minutely drawn up, and from his few introductory remarks he seems to be animated by the true scientific spirit, for he says of them: "If they even serve to identify the species, they may be considered to have done their duty."

IT is known that Clymenias, so widely spread in the Devonian deposits of Western Europe, have not yet been found in Russia—with the exception, perhaps, of the *Clymenia undulata* in the hills of Kielce in Poland. Now, Prof. Karpinsky has discovered remains of this Cephalopod on the Asiatic slope of the Ural, near Verkne-uralsk (*Izvestia* of the Russian Geological Committee, 1884, No. 4). The Uralian fossil is very much like *Clymenia annulata*, Münster, and the few differences render it more like *Clymenia nodosa*, Münster, which is considered by Keyser and Gümbel merely as a variety of the foregoing. Another Clymenia, also found in the same locality, but in a worse state of preservation, seems to belong to *C. striata*. This discovery, while establishing one more feature in common for the Russian and West European Devonian, at the same time widens very much the area of distribution of the Clymenias, formerly so strictly limited to Western Europe.

A NOTE on a possible source of error in photographing blood corpuscles, by Mr. G. St. Clair, F.G.S., communicated to the Birmingham Philosophical Society, is a fruitless attempt to explain as an optical illusion Dr. Norris's asserted discovery by the aid of photography of a third kind of corpuscle in mammalian blood. The author invokes the principle of the formation of images by the passage of light through small apertures, and conceives that Dr. Norris's "colourless disks" are merely images of the end of the microscope tube or the aperture of the eyepiece, and he seems to have taken some pains to obtain such images by placing under the microscope a slide thickly strewn with small steel disks, and receiving the light on a screen beyond the eyepiece. Had he attempted to focus these ghosts and the real images of the disks *at the same time*, or considered a little more closely the elementary optical principles involved, we venture to say the note would never have been written.

AT the last meeting of the Asiatic Society of Japan a paper was read by Mr. O. Korschelt on "The *Tenken* system of Japanese fortune-telling." The Japanese calendar forms the basis of the system, and by an application of certain rules to the date of a man's birth, his character can be determined. The qualities assigned to each year, month, and day, each of which is represented by one of twelve letters of the syllabary, seem to have some resemblance to the characters of the corresponding calendar animals—tiger, hare, dragon, serpent, &c. From the five syllabary letters corresponding to the year and month of conception, and the year, month, and day of birth, the chief points of a person's character are made out—the most important determining factors being the year of birth and month of conception. Then come to be considered the effect of the stars which are supposed to rule the years, months, and days. For each year there are nine stars, which have their special qualities; and each man's life is to be ruled by one of them. From the mutual relation of these stars, the life relations of two given people can be made out. One very important application of the system amongst the Japanese is the comparison of the ruling stars of two who are contemplating marriage. Similarly, as each instant of time is ruled by a star, it can be determined whether a given year, month, or day will be lucky or unlucky to a certain individual. The method of divination thus described was illustrated by examples, the author having worked out the horoscopes of Cromwell, Carlyle, Bismarck, Napoleon, and other historical characters. From the discussion which followed, it appears that this elaborate system can be traced back to the earliest period of recorded time in China. It is the so-called system of philosophy embodied in the "Yiking," the oldest of all Chinese books, and if it should turn out, as is contended by some eminent Chinese scholars, that this work is not Chinese in its origin, but Accadian, then Japanese divination would be a Western product.

THE *Japan Gazette* reviews a publication by the native Professor of Botany in the University of Tokio, entitled "Nomenclature of Japanese Plants in Latin, Japanese, and Chinese." The list, it appears, does not include all the plants indigenous to Japan, while it includes many which are in no sense Japanese. It is inferior to Franchet and Savatier's "Enumeratio Plantarum Japonicarum," for while the latter gives more than 2700 distinct species of indigenous flowering plants and ferns, the consecutive numbering in the native work only runs up to 2406, and this includes, besides many foreign plants, numerous mere varieties of species, to each of which a separate number has been appropriated. The author, Mr. Matsumura, is said to contemplate the publication of a more elaborate work.

THE additions to the Zoological Society's Gardens during the past week include a Purple-faced Monkey (*Semnopithecus leucoprymnus*) from Ceylon, two Laughing Kingfishers (*Dacelo gigantea*) from Australia, presented by Mr. D. Palgrave Turner; a Lesser White-nosed Monkey (*Cercopithecus petaurista*) from West Africa, presented by Mrs. E. A. Alldridge; a Cape Hunting Dog (*Lycaon pictus*) from the South-West Coast of Africa, presented by Capt. J. Grant Elliott; a Tigrine Cat (*Felis tigrina*), two Ring-tailed Coatis (*Nasua rufa*) from Brazil, presented by Mr. James Meldrum; a Herring Gull (*Larus argentatus*), British, presented by Miss J. Dunford; a Yellow-fronted Amazon (*Chrysotis ochrocephala*) from Guiana, presented by Mrs. Frank Wilson; three Violaceus Night Herons (*Nycticorax violaceus*) from South America, presented by Mr. A. Boon; two Yellow-winged Sugar Birds (*Cœreba cyanea* ♂ ♂) from Brazil, presented by Mr. P. A. Fraser; a Tuberculated Iguana (*Iguana tuberculata*) from Brazil, presented by Mr. J. H. Leech; a Brown Capuchin (*Cebus fatuellus*), a Weeper Capuchin (*Cebus capucinus*) from Brazil, a Malbrouck Monkey (*Cercopithecus

cynosurus) from West Africa, two Victoria Crowned Pigeons (*Goura victoriæ*) from the Island of Jobie, deposited; three Ruddy Flamingoes (*Phœnicopterus ruber*) from North America, purchased; two Ring-tailed Lemurs (*Lemur catta*), a Great Kangaroo (*Macropus giganteus* ♂), born in the Gardens.

OUR ASTRONOMICAL COLUMN

ASTRONOMICAL PHOTOGRAPHY.—M. Mouchez, the Director of the Observatory of Paris, has communicated to the Academy of Sciences a brief account of some experimental attempts to photograph very small stars, which have been lately made at that establishment. The ecliptical star-charts, commenced by Chacornac, but interrupted in their formation by his decease, were taken up by MM. Paul and Prosper Henry in 1872. These charts include all stars to the thirteenth magnitude; thirty-six of the entire number of seventy-two required for the whole ecliptical zone were completed by Chacornac; these contain 60,000 stars; while sixteen more, containing 36,000 stars, have been constructed by MM. Henry, who will shortly finish four others, with 15,000 stars. But they now find themselves in face of a difficulty which can hardly be overcome by the ordinary process of charting. The condensation of stars in those regions where the Galaxy traverses the ecliptic is so great as apparently to defy an accurate and complete representation of their stellar contents, on the methods adopted for the greater part of the zone, notwithstanding all the experience and well-known skill of the observers.

They have accordingly had recourse to photography, and their first attempts with a provisional apparatus have succeeded so well that there is every reason to expect by this means a solution of the difficulty in question. On plates covering an extent of 3° in right ascension and 2° in declination, obtained with an objective of 0·16 m. diameter and 2·10 m. focal distance, achromatised for the chemical rays—which M. Mouchez exhibited to the Academy—there are shown some 1500 stars from the sixth to the twelfth magnitude, *i.e.* to the limit of visibility of an objective of that size; the images of the stars have diameters nearly proportional to their brightness, except in the case of the yellow stars, which come out somewhat fainter. These encouraging results have led MM. Henry to commence the construction of a large objective of 0·34 m. diameter, which will be mounted by M. Gautier, and it is anticipated that with this instrument, in the course of an hour, a chart of the stars, to the twelfth magnitude at least, and probably to the thirteenth or fourteenth, of the same dimensions as one of the published charts, will be obtained; a work which would otherwise require many months of assiduous labour.

THE BRITISH ASSOCIATION CATALOGUE OF STARS.—In a book-list circulated during the last week by a Dresden firm, a copy of this Catalogue has a price of 200 marks (10*l.*) attached, excused by the addition, "Aeusserst selten." As regards star-places the volume is out of date, and the same may be said of the so-called constants for reduction of mean to apparent positions, if any degree of accuracy be required; but it is nevertheless still sought after, especially by those who are commencing the study of astronomy, as will be well known to every one who has any pretence to be considered a practical authority; and it must be admitted that, for purposes of identification and for synonyms in some of the principal older catalogues, the B.A.C. has still its uses. The question arises, whether there would not be a considerable demand for a new general Catalogue of the principal stars, or of stars to the limit of naked-eye vision, brought up from the best authorities to, say, the epoch 1900, but unencumbered with the reduction-quantities, which would materially diminish the expense of formation. A Catalogue of this description, we take it, is not likely to be again provided from the funds of such a body as the British Association, and perhaps the most feasible method of producing it would be by way of subscription. One difficulty would no doubt consist in securing a supervisor of the plan and formation of the work;—perhaps few competent persons could be named who have the leisure which Baily fortunately possessed, and to which we owe not only the B.A.C. but the Catalogues of Lalande and Lacaille.

THE COMET 1884*b*.—Prof. Krueger's telegram to Melbourne led to the observation of this comet, both by Mr. Ellery and Mr. Tebbutt on July 24. Mr. Tebbutt sends us several letters which he has addressed to the *Sydney Morning Herald*.

THE BRITISH ASSOCIATION

REPORTS

Report of the Committee, consisting of Dr. Gladstone, F.R.S. (Secretary), Mr. William Shaen, Mr. Stephen Bourne, Miss Lydia Becker, Sir John Lubbock, Bart., M.P., F.R.S., Dr. H. W. Crosskey, Sir Henry E. Roscoe, F.R.S., Mr. James Heywood, F.R.S., and Prof. N. Story Maskelyne, M.P., F.R.S., for the Purpose of Continuing the Inquiries relating to the Teaching of Science in Elementary Schools.—Since the reappointment of your Committee at Southport no legislation affecting the teaching of science in elementary schools has taken place, and it is yet too early to estimate the whole influence of the Education Code of 1882 in that respect. Some indications, however, have been gathered from the Blue-book and from some of the large Boards. The first effect of the change of Code upon the teaching of science is shown in the return of the Education Department for this year; but as the tabulated statements only extend to August 31, 1883, they contain merely the results of those examinations that were made of schools which came under the new Code between April 1 and August 1, 1882, or about 28 per cent. of the whole. The following conclusions may be drawn: (1) Elementary science was taken up by scarcely any schools examined during these months, the number of departments that took it up as the second class subject being only 15, while 3988 took up geography, 1644 (girls) needlework, and 114 history. It must be remembered that geography is more scientific than it was before, but needlework is rapidly displacing it in girls' schools. (2) The exclusion of the Fourth Standard from instruction in specific subjects has reduced the number of scholars so taught by 56·6 per cent.; but the remaining 43·4 per cent., that is to say, the children in Standards V., VI., and VII., do receive a larger proportion of scientific teaching. The actual number of children examined during these four months in the mathematical and scientific specific subjects is given in Column I. of the following table; Column II. gives the estimated number who would have been examined under the old Code; Column III. the number of those who would have been above Standard IV.

Subject	Col. I.	Col. II.	Col. III.
Algebra	8,256	1,847	799
Euclid and Mensuration	604		
Mechanics, Scheme A	635	1,393	603
" Scheme B	—		
Animal Physiology	7,078	8,537	3,696
Botany	1,020	642	278
Agriculture (principles of)	422	—	—
Chemistry	368	—	—
Sound, Light, and Heat	196	—	—
Magnetism and Electricity	1,133	—	—
Domestic Economy	6,090	16,890	7,232
Totals	25,802	29,309	12,608

Comparing Columns I. and II., it will be seen that the actual number examined in these subjects is not much less than would have been examined under the old Code, when the Fourth Standard was included; but the number of girls who have taken up domestic economy is 10,800 less. If we compare Column I. with Column III., which embraces the same Standards, it appears that double the number of children have passed in these mathematical and scientific subjects. This is, no doubt, mainly due to the fact that English literature and physical geography are removed to the category of class subjects. The great gain has evidently been to the study of algebra, that subject and Euclid being taken up by about eleven times as many as previously took up mathematics. Animal physiology and botany have also largely increased. Mechanics is about the same, while of the new subjects magnetism and electricity has proved itself the favourite, while agriculture, chemistry, and sound, light, and heat follow in order. The only subject that has actually lost ground is domestic economy, which is no longer obligatory in girls' schools if a specific subject is taken. The following table gives the number of passes in specific subjects made by the London School Board children in 1881–82, and in 1883–84. The second column gives the estimated number of those that were made in Standards above IV., corresponding to Column III. in the previous table.

Subject	1881-82 Standard IV. and upwards	1881-82 Over Standard IV.	1883-84
Algebra	213	101	3,113
Euclid and Mensuration			139
Mechanics	48	23	165
Animal Physiology	8,667	4,094	5,657
Botany	534	252	686
Agriculture (principles of)	—	—	299
Chemistry	—	—	198
Sound, Light, and Heat	—	—	179
Magnetism and Electricity	—	—	825
Domestic Economy	9,597	4,533	3,478
Totals	19,059	9,003	14,739

The following information has been furnished from the Manchester School Board:—

I. Class subjects.

Departments	1882 Grammar	1882 Geography	1882 Needlework	1882 History	1883-84 English	1883-84 Geography	1883-84 Needlework
Boys	26	24	—	1	31	30	—
Girls	26	11	8	1	28	4	23
Junior	13	10	—	—	21	13	3
Mixed	4	—	1	—	4	—	3
Totals	69	45	9	2	84	47	29

Historical and geographical readers are provided in every department, and even though the subject be not taken for the Government examination the children are always questioned on the matter of the reading-books by the Board's Inspector.

II. Specific subjects (scientific).

Subject		Departments 1882 Boys	1882 Girls	1884 Boys	1884 Girls
Algebra	Mathematics	4	—	13	1
Euclid and Mensuration				1	—
Mechanics		3	—	1	—
Animal Physiology		2	—	2	—
Botany		1	—	—	3
Domestic Economy		—	10	—	2
Totals		10	10	17	6

III. Science teaching under the Science and Art Department is given as follows:—

Subject	Departments Boys	Girls
Mathematics	3	2
Physiology	1	1
Chemistry	3	2
Sound, Light, and Heat	2	2
Magnetism	2	2
Totals	11	9

The Brighton School Board had the following number of children studying the specific subjects during the quarter ending March 25, 1884:—

	Boys	Girls
Algebra	285	—
Euclid and Mensuration	13	—
Animal Physiology	292	6
Magnetism and Electricity	149	—
Domestic Economy	—	261

As to class subjects, the ten boys' departments all take up geography as the second, the number of children under instruction being 2879; while only one girls' department, with 119 children, takes geography for the Government examination, though it is taught in most of the others through reading lessons. The other nine girls' departments, with 2339 children, take needlework as the second class subject. At the Southport meeting a recommendation was passed that this Committee "be requested to consider the desirableness of making representations to the Lords of the Committee of Her Majesty's Privy Council on Education in favour of aid being extended towards the fitting up of workshops in connection with elementary day schools or evening classes, and of making grants on the results of practical instruction in such workshops under suitable direction, and, if necessary, to communicate with the Council." As it was believed that the second Report of the Royal Commissioners on Technical Instruction would have an important bearing upon this question, the Committee was not called together till the publication of that Report. It was not issued till May, and it then appeared that, in addition to a very large amount of valuable information, the Royal Commissioners had recommended, among other things:—"(*b*) That there be only two class subjects instead of three in the lower division of elementary schools, and that the object lessons for teaching elementary science shall include the subject of geography." "(*d*) That proficiency in the use of tools for working in wood and iron be paid for as a specific subject, arrangements being made for the work being done, so far as practicable, out of school hours. That special grants be made to schools in aid of collections of natural objects, casts, drawings, &c., suitable for school museums." With reference to recommendation (*b*) your Committee, without expressing any opinion as to the desirability of forming one subject out of geography and elementary science, consider that, if this change be effected, the two class subjects which will then represent literature and science should stand upon an equal footing. This would be in accordance with the resolution of the Council passed on December 5, 1881, in considering the recommendations of your Committee in regard to the proposals for the new Code. At present, if only one class subject is taken, the Code requires that it should be "English" (grammar and literature); but many managers or teachers might prefer taking science. With respect to recommendation (*d*) your Committee thoroughly approve of the proposals, which, if carried out, would realise the wish expressed in the reference to them from the Southport meeting. They have not, however, thought it necessary to communicate at once with the Council, as there is no immediate legislation in prospect, and the meeting at Montreal might like to give further instructions on the subject. The name of Prof. N. Story Maskelyne, M.P., has been replaced on the Committee.

Report of the Committee, consisting of Sir Joseph Hooker, Dr. Günther, Mr. Howard Saunders, and Mr. P. L. Sclater (Secretary), appointed for the Purpose of Exploring Kilimanjaro and the Adjoining Mountains of Eastern Equatorial Africa.—(1) The Committee have the satisfaction of announcing that they have made arrangements with Mr. H. H. Johnston (who has recently returned from the Congo) to undertake an exploration of Kilimanjaro, and that he is probably by this time encamped upon that mountain. (2) The Committee have arranged with Mr. Johnston to undertake the cost of the expedition for 1000*l.*, without reference to personal remuneration. It is believed that the necessary expenditure will not be covered by this sum, but Mr. Johnston has agreed to make good any deficiency. (3) Towards this sum of 1000*l.* the Committee have appropriated a sum of 500*l.* granted to them by the Association at their last meeting at Southport. The Committee have also received from the Government Grant Committee of the Royal Society two sums of 250*l.* each, so that the whole sum of 1000*l.* required for the expedition is already available. (4) But looking forward to the risks of African travel, and to the expenditure likely to be incurred on the transport to this country, and on the working out of the collections obtained by Mr. Johnston, the Committee trust that a further sum of 50*l.* may be placed at their disposal. (5) A copy of part of Mr. Johnston's last letter to the Secretary of the Committee, containing an account of the progress of the expedition, is annexed to this Report.

Extracts from a letter from Mr. Johnston to Mr. Sclater, dated British Residency, Zanzibar, May 13, 1884:—"At last my expedition, thanks to the help of Sir John Kirk, is organised and ready to start. I have engaged thirty-two men here (at Zanzibar), and have sent them off to Mombasa in a dow to await my coming. I myself leave to day for Mombasa in the mail. At Mombasa, through the Consul (Capt. Gissing), I have engaged sixty more men, for it will need nearly a hundred porters to carry my goods and baggage to Chagga. I hope to leave Mombasa in a fortnight's time. I anticipate three weeks' easy travel to Kilimanjaro, and, as far as it is possible to foretell aught in Africa, no serious difficulties seem to stand in my way. The expedition, however, will prove much more costly than I had anticipated. . . . However, I think I shall be able to make both ends meet for six months on Kilimanjaro, and if I stay longer, or make a dash at Kenia, it will be on my own account. I shall *probably* make Taita or Teita (*vide* map) a half-way house, and go backwards and forwards with collections and

goods. I shall try to forward collections addressed to you by *every mail* if feasible. Then, if you judge of the value, and estimate that my share of the collections will realise a good amount, it will induce me to devote more time to the country. My health, notwithstanding a much more trying climate than I have yet met with in Africa, has been very good, and I have not known an hour's illness or indisposition. Sir John Kirk has shown me the utmost kindness and hospitality, and his help and his influence have smoothed away many difficulties. The expedition promises most favourably, as the present condition of the countries to be traversed is good and peaceful, food abundant, and provisions cheap. . . . . I have obtained the services of three of Dr. Fischer's bird-skinners, and have got one botanical collector, trained under Sir John Kirk, and acquainted with the mysteries of 'soldering' and preserving in spirit. I have sent for rectified spirit from Bombay, and in the interval am using trade gin. The Sultan has given me three kegs of gunpowder to give as presents to chiefs, and has also furnished me with letters of introduction. I am in excellent condition, and start to-day on my journey in the best spirits and with the strongest hopes of its success."

Report of the Committee, consisting of Mr. James N. Shoolbred (Secretary) and Sir William Thomson, appointed for the Purpose of Reducing and Tabulating the Tidal Observations in the English Channel made with the Dover Tide-Gauge, and of Connecting them with Observations made on the French Coast.—The Committee beg to report that the tidal curves of the self-registering tide-gauge at Dover for the years 1880, 1881, 1882, and 1883, have been kindly placed at their disposal by the Board of Trade, for reduction and tabulation; and that the Belgian Government have been good enough to present to the Committee copies of the tidal curves at Ostend during the same period of four years. The reduction and tabulation of the high and low water registers of these two sets of tidal curves has progressed satisfactorily, and will be shortly completed. It is hoped also that a like reduction will be soon commenced with other self-registering tidal curves during the same period at several other points, both on the English and the French coasts. The Committee request to be allowed to transmit to the Board of Trade and to the Belgian Government respectively, the thanks of the Association for their assistance and donations in furtherance of this inquiry. The Committee request to be re-appointed, with a grant of 10*l*. to defray the expenses of reduction, &c.

Report of the Committee, consisting of Prof. Balfour Stewart (Secretary), Prof. Stokes, Mr. G. Johnstone Stoney, Prof. Roscoe, Prof. Schuster, Capt. Abney, and Mr. G. J. Symons, appointed for the Purpose of Considering the Best Methods of Recording the Direct Intensity of Solar Radiation.—This Committee, acting on a suggestion made by Gen. Strachey, have chiefly devoted their attention to the subject of a self-recording actinometer. The self-recording actinometer of Mr. Winstanley would not be suitable,[1] because it is influenced by radiation from all quarters. Other actinometers require manipulation on the part of the observer which would make it almost impossible to make them self-recording. It was suggested by Prof. Balfour Stewart that a modification of his actinometer might be adapted to self-registration by taking for the quantity to be observed, not the rise of temperature of the inclosed thermometer after exposure for a given time, but the excess of its temperature when continuously exposed over the temperature of the envelope. After making some calculations as to the behaviour of such an instrument, Prof. Stokes came to the following conclusions:—(1) The inclosure should be of such a nature as to change its temperature very slowly, and of such a material that the various portions of the interior should be at the same moment of the same uniform temperature. For this purpose an arrangement somewhat similar to that used in Prof. Stewart's actinometer is suggested; the outside to consist of polished metallic plates, then a layer of some non-conducting substance, such as felt, then a thick copper interior which need not be polished. Into this copper is to be inserted a thermometer which will give the temperature of the copper interior from moment to moment.

1 "This is the case at present, but there would not be any great difficulty in modifying it so as to act as required. It is quite a matter worth consideration whether a differential air-thermometer would not be very suitable, one bulb silvered and the other blackened or of green glass, as I suggested to the Meteorological Council some years back. By this means only *one* reading would be necessary, whilst in the plan suggested two would have to be recorded, and the measurements would be more difficult." (*Note by Capt. Abney.*)

(2) In the middle of the inclosure is to be placed the thermometer, upon which the heat of the sun is made to fall by means of a hole in the inclosure, either with or without a lens. This thermometer should be so constructed as to be readily susceptible to solar influences. It is proposed to make it of green glass (a good absorber and radiator), and to give it a flattened surface in the direction perpendicular to the light from the hole. Such an instrument should be so adjusted as to receive the sun's light continuously through the hole, and the objects of record would be the simultaneous heights of the two thermometers, the one giving the temperature of the inclosure, and the other of the central thermometer. There are two conceivable methods by which the necessary adjustment with regard to the sun's light might be secured, namely, (α) the inclosure might be subject to an equatorial motion so as to follow the sun, or (β) the inclosure might be kept at rest and the solar rays kept upon the hole by a heliostat. Capt. Abney is of opinion that the latter arrangement is, mechanically, much preferable to the former. As the direction of the earth's axis may be chosen as that into which the sun's light is to be reflected, a heliostat of a very simple construction will suffice; and as the angle of incidence on the mirror of such a heliostat changes only very slowly with the season, there is no difficulty in applying the small correction required for the change in the intensity of the reflected heat consequent on the change in the angle of incidence. It is assumed that the mirror of the heliostat is a speculum. It has been remarked by Gen. Strachey that some such instrument as this now suggested, even if not made self-recording, would have the advantage of giving an observation without the objectionable necessity of putting the light on for a given time, and then shutting it off, operations only suitable for trained observers. We think that it would be desirable to construct an inclosure with its two thermometers such as herein recorded. In all probability the loan of a heliostat and of an actinometer might be obtained. By aid of the heliostat the sun's light might be kept continuously upon the hole of the inclosure. The two thermometers would be read, and the results compared with the simultaneous reading of an ordinary actinometer. By such means it is believed that the best method of constructing such an instrument and observing with it might be found. We would therefore ask for a continuance of our Committee, with the sum of 30*l*. to be placed at our disposal for the purpose herein specified.

Report of the Committee, consisting of Mr. Sclater, Mr. Howard Saunders, and Mr. Thiselton Dyer (Secretary), appointed for the Purpose of Investigating the Natural History of Timor Laut.—Since our last report was presented to the Association, Mr. Forbes's botanical collection—which, from the result of an unfortunate fire in the drying-house in which the Herbarium had to be prepared, was very small, as he deplores—has been handed over to the Royal Herbarium at Kew. Of this collection Sir Joseph Hooker, at a meeting of the Royal Geographical Society on January 28, 1884, made the following remarks:—"From that time [of the appearance of Prof. Decaisne's 'Flora Timoriensis'] to this, the limits of the Australian flora, so long supposed to have been circumscribed with exactitude, have never been laid down, though it has been enormously enlarged to the north by the inclusion of the great island of Papua, which is to a great extent Australian in its biology, and by that of sundry other islets to the north-east and north-west. It is under this point of view that Mr. Forbes's collections are so important. It is true that for the most part they consist of what are generally known as *coral-island* plants. . . . But besides this there are some peculiar forms, and there are two plants of extraordinary interest which I would simply instance as being typical—one of the new Hebridean and one of the Australian flora. It so happened that these two plants belonged to unispecific genera. . . . The existence of these plants pointed to some old communication between these particular islands." No detailed account of the ethnographical collection has yet been published; but as the collection has been deposited in the British Museum, a description of the Timor Laut objects will doubtless appear in the Catalogue of the Ethnological Department, while the more interesting will be figured in Mr. Forbes's forthcoming volume. At the last meeting of the Association at Southport, Dr. J. G. Garson ("Report," p. 566) read a short account of the crania (now in the British Museum) brought from Larat by Mr. Forbes, which has been published *in extenso* in the *Journal* of the Anthropological Institute, vol. xiii., and which concludes with the following remarks on the relation of the inhabitants of

Timor Laut to those of adjacent countries:—"That the skulls just described are not those of a pure race is very evident. Two very distinct types can be made out, namely, the brachycephalic and the dolichocephalic, the former greatly predominating in number. Both from the information Mr. Forbes has given us as to their appearance, and from the skulls themselves, there is no difficulty in recognising a strong Malay element in the population. The male skull No. 4, and the female No. 6, are typically Malayan in their characters, especially in possessing large, open, rounded orbits, and smooth forehead, the superciliary ridges and glabella being almost entirely absent. The other brachycephalic skulls, though not presenting such a striking affinity, agree more or less with this type, but give evidence of mixed characters. The dolichocephalic skull is, on the other hand, markedly of the Papuan type, and corresponds so closely as to be undistinguishable from two crania obtained twenty miles inland from Port Moresby, New Guinea, in the College of Surgeons' Museum, also from another from the Solomon Islands. Along with this form of skull, Mr. Forbes informs me, is associated frizzly hair and dark skin. The examination of the cranial characters of the inhabitants of Timor Laut, as illustrated by the skulls before us, shows that the peopling of this island is no exception to what is usually found in the various groups of islands in the Polynesian Archipelago. From its close proximity to New Guinea, perhaps more of the Papuan element might have been expected." In addition, the *Coleoptera* sent home have been examined and described in a recent paper by Mr. C. O. Waterhouse, published in the Zoological Society's *Proceedings*. The number of species collected was twenty-nine; of these the following deserve special notice on account of their geographical distribution:—*Diaphates rugosus*, a new genus and species of *Staphylinidæ* known from Java; *Cyphogastra angulicollis*, only previously known from Banda; *C. splendens*, a new species allied to the preceding; *Archetypus rugosus*, belonging to a genus of Longicorns, of which there was only one species previously known, which species occurs in Waigiou, Dorey, and Aru; *Nemophas forbesii*, a new Longicorn nearly allied to *N. grayi* from Amboina. Further, a new species of ground thrush (*Geocichla machiki*) has been described by Mr. Forbes from additional specimens brought home by himself on his return. So that our knowledge of the avifauna of this region has been increased by the addition of twenty-four new species, entirely collected on the few square acres to which the inter-tribal wars of the natives restricted Mr. Forbes's operations. At the presentation of our last report, Mr. Forbes, who had just returned to England, gave a short description of the region visited by him; but at the meeting of the Royal Geographical Society, to which we have referred above, he gave a more detailed account, which has been published, illustrated by a map, in their *Proceedings* for March, embodying the geographical observations made by him. The collections of Fishes, Crustacea, and Hydrozoa, though containing much that was of interest, added few species that were new to science. A statement in our last report, on p. 227, that "the total expense of Mr. Forbes's expedition has amounted to 300*l*." ought perhaps to be corrected, as we understand from Mr. Forbes that the total cost was more than double this sum.

Report of the Committee, consisting of Mr. John Cordeaux (Secretary), Prof. Newton, Mr. J. A. Harvie-Brown, Mr. William Eagle Clark, Mr. R. M. Barrington, and Mr. A. G. More, reappointed at Southport for the Purpose of Obtaining (with the Consent of the Master and Brethren of the Trinity House and the Commissioners of Northern and Irish Lights) Observations on the Migrations of Birds at Lighthouses and Light-vessels, and of reporting on the same.—The General Report[1] of the Committee, of which this is an abstract, comprises observations taken at lighthouses and light-vessels, as well as at several land stations, on the east coast of England, the east and west coasts of Scotland, the coasts of Ireland, also the Channel Islands, Orkney and Shetland Isles, the Hebrides, Faroes, Iceland and Heligoland, and one Baltic station on the coast of Zealand, for which the Committee is again indebted to Prof. Lütken of Copenhagen. Altogether 158 stations have been supplied with schedules and letters of instruction for registering observations, and returns have been received from 102. The best thanks of the Committee are due to their numerous observers for the generally careful and painstaking manner in which they have filled up the schedules, and the very intelligent interest taken by them in the inquiry. Special thanks must be accorded to Messrs. H. Gätke, Heligoland; H. C. Müller, Faroe; and M. Thorlacius, Skykkesholm, Iceland, for the notes sent in from their respective stations; also to Mr. J. H. Gurney, for having commenced on the south-east coast of England a similar system of inquiry, which, for a first trial, has worked well. In all doubtful cases of identity, where birds are killed against the lantern, a wing is cut off, and a label, with the date, attached. These have been forwarded in batches to Mr. Gurney for identification, and with most satisfactory results. The Committee regret that for the second year in succession they have received no report from the west coast of England. A late member of the Committee, Mr. Philip M. C. Kermode, having failed to make any returns, or to send the collected schedules, although repeatedly requested, to Mr. W. E. Clarke, who had undertaken the work of tabulating and reporting on the same, provision has been made by the Committee for supplying the deficiency in any subsequent years. The observations taken on the east coast of Great Britain in 1883 have been such as generally to confirm the conclusions arrived at in former reports, having reference to direction of flight and lines of migration. The winter of 1883-4 has been exceptionally mild, and there has been an almost entire absence of severe frosts and lasting snowstorms; the prevailing winds in the autumn, west and southwest, such as observation shows are most favourable for migrants crossing the North Sea and continuing their journey inland. Winds from opposite quarters to these tire out the birds and cause them to drop directly they reach land. Our land stations report a great scarcity both of land and sea birds; this has not, however, been the case at sea stations—that is, light-vessels moored off the coast at distances varying from five to fifty miles. Here the stream of migration, so far from showing any abatement, has flown steadily on in a full tide; and, if we judge from the well-filled schedules which have been returned, there has been a considerable increase in the visible migration, due perhaps in some measure to increased interest and improved observation. Mr. William Stock, of the Outer Dowsing light-vessel, remarks that he had never before seen so many birds pass that station; the rush, also, across and past Heligoland in the autumn was enormous. Migration is more marked, as well as concentrated, there, than at any station on the English coast. There was a great movement of various species passing forward on August 6 and 7, and again on the 14th, and more pronounced still on the 21st and 22nd, and on August 20 a similar movement was noticed at the Isle of May, at the mouth of the Firth of Forth. It was not, however, until September 21 and the two following days that the first great rush occurred on the English east coast, and a similar great movement or rush is indicated, at the same date, in Mr. Gätke's notes, as well as from the most distant of the lightships. The prevailing winds over the North Sea on September 21 were moderate north-easterly and easterly off the coasts of Denmark and Holland, blowing strong easterly on the coast north of the Humber, with southerly and south-westerly off the south-east coast, producing cross-currents over the North Sea. Whatever was the impulse, atmospheric or otherwise, which induced such a vast rush of various species at this time, it was one which acted alike, and with precisely the same impulse, on the sea-eagle and the tiny goldcrest. The second great rush was on October 12 and 13, a similar movement being recorded at Heligoland. Then, again, from the 27th to the 31st, and somewhat less through the first week in November, the passage across Heligoland, as well as the rush on our east coast, was enormous. Speaking of the nights from the 27th to the 31st inclusive, Mr. Gätke says: "This was the first move by the million; for four nights there has been a gigantic feathery tide running." During this time there were variable winds over the North Sea, but generally easterly and south-easterly on the Continent, strong west winds and squalls prevailing generally on November 5 and 6. Again, with the outburst of some severe weather in the first week in December, a considerable local movement is indicated along the coast from north to south, culminating in the enormous rush of snow-buntings into Lincolnshire about the end of the first week in that month. A careful perusal of the report will show how generally the rushes across Heligoland correlate with those on the east coast of England, although not always confined to identical species. A somewhat remarkable and very anomalous movement of migrants is recorded from light-vessels of the Lincolnshire and Norfolk coasts in the spring of 1883. In February, March, April, and May, birds passing the Leman and Ower, Llyn Wells, Outer Dowsing, Newarp and the Cockle light-

[1] "Report on the Migration of Birds in the Spring and Autumn of 1883." (West, Newman, and Co., 54, Hatton Garden, London, E.C.).

vessels, were, as a rule, coming from *easterly* and passing in *westerly* directions. The entries show a great immigration of our ordinary autumn migrants from the east in the spring months, and on exactly the same lines and directions as are travelled by the same species in autumn. Had this movement been observed at one station only, we might perhaps have been induced to doubt the accuracy of the return, but the fact of five light-vessels, having no communication with each other, reporting the same circumstances, proves the correctness of the observations. On the east coast of Scotland Mr. J. A. Harvie-Brown says that the autumn migration of 1883 was pronounced, culminating in a grand rush from October 28 to November 3. The heaviest rush of birds, as compared with other years, was observed at the Isle of May on October 13 and 14. This was with a south wind, although as a rule it is a south-east wind at that point which brings the greatest flights. In the autumn of 1882, on the east coast of Scotland, the bulk of immigrants are recorded at the southern stations; in 1883 these conditions were reversed, the bulk being recorded from northern stations. On the east coast of England, in 1883, birds appear to have been very equally distributed over the whole coast-line. It will be gathered from the General Report that the dates of the rushes on the east coast of Scotland were slightly later than those on the east coast of England, and that the migrations past the more northerly stations in Scotland were in proportion later than in the south, and also that the dates of the heaviest rushes on the east coast agree fairly with the dates from the west coast. From the coasts of Ireland Messrs. A. G. More and R. M. Barrington report a decided improvement in filling up the schedules, in some cases three or four being returned from the same station. Forty-two stations were supplied with schedules in the spring of 1883, and thirty-five in the autumn of the same year, returns coming in from thirty-four, one only failing. The number of migrants in the autumn seems to have been more than usual. A great rush of thrushes (including, probably, redwings), blackbirds, and starlings, took place at the south-eastern and southern stations between October 25 and November 2—dates which agree with the great rush on the east coast of England. The migration was particularly marked at the Tuskar Rock, off the Wexford coast, which is proving itself the best Irish station, and no doubt marks the line of the chief passage from the British coast. The bulk of the immigrants appear to arrive on the south-eastern coast of Ireland, excepting such birds as the bernicle-goose and snow-bunting, which are mainly recorded from north-western stations, and rarely entered in schedules from the east or south coast. An interesting feature this year is the occurrence of several examples of the Greenland falcon on the west coast, no less than eight having been shot at various points from Donegal to Cork, and one Iceland falcon at Westport. Independent of the ordinary notes on migration, the general remarks of the light-keepers with reference to the nesting of sea-fowl on the islands or outlying skerries are of great interest, and no matter what results are arrived at from this special inquiry, it is satisfactory to be in correspondence with such a number of observers at isolated spots around the coast, and the information supplied cannot fail to be of much interest to future compilers. An interesting feature of the autumn migration is the occurrence of a flight of the blue-throated warbler (*Cyanecula suecica*). A single adult with bright-blue breast was observed at the Isle of May on the night of September 2–3. On the east coast of England twelve were obtained, all being birds of the year, and of these nine on the coast of Norfolk, besides about twenty others seen by competent observers. Very few goldcrests, compared with the enormous flights of the previous autumn, have appeared, and the same scarcity is observable in the Heligoland returns. Curiously enough, the hedge-sparrow (*Accentor modularis*), which migrated in immense numbers in the same autumn, has been almost entirely absent. About half a dozen are recorded at Heligoland, none on the east coast of England. Of the enormous immigration which crosses our east coast in the autumn, either to winter in these islands or merely on passage across them, a small proportion only appear to return by the same routes. Spring returns from lighthouses and light-vessels show that birds then move on the same lines as in the autumn, but in the reverse direction. These return travellers do not, however, represent anything like a tithe of the visible immigrants which, week after week and month by month, in the autumn, move in one broad stream on to the east coast. What is called the "first flight" of the woodcock arrived on the Yorkshire, Lincolnshire, and Norfolk coasts on the night of October 21. The "great flight," or rush, which covered the whole of the east coast from the Farne Islands to Yarmouth was on the nights of the 28th and 29th. These two periods correlate with the principal flights of woodcock across Heligoland. But few woodcock were recorded from stations on the east coast of Scotland, although at the Bell Rock Lighthouse, on the night from October 31 to November 1, Mr. Jack reports an enormous rush of various species, commencing at 7 p.m. Immense numbers were killed, pitching into the sea. "What we thought were woodcocks struck with great force; birds continued flying within the influence of the rays of light till the first streak of day, continually striking hard all night; we believe a great number of woodcocks struck and fell into the sea." Mr. Harvie-Brown records a very great spring migration of woodcock which appear to have crossed Scotland between the Clyde and the Forth on March 9, 10, 11, and 12, 1884. These were observed to be the small red Scandinavian bird, which are quite unmistakable and distinct from British-bred birds. The occurrence of *Locustella fluviatilis* at the Stevns Lighthouse at the entrance of the Oresund in Zealand is interesting, as it is the first recorded Danish example of this species. Altogether there has been a very marked absence on our British coasts of rare and casual visitants. The roller (*Coracias garrula*) occurred in October in two localities—one in Lincolnshire, the other in Suffolk. Two examples of the sooty shearwater (*Puffinus griseus*) were obtained in Bridlington Bay about the end of September. The island of Heligoland retains its pre-eminence as the casual resting-place of rare wanderers from other lands; and Mr. Gätke's list for 1883 includes *Turdus varius*, *Pratincola rubicola*, var. *indica*, *Phylloscopus superciliosus*, *Hypolais pallida*, *Motacilla citreola*, *Anthus cervinus*, *A. richardi*, *Oriolus galbula*, *Lanius major*, *Muscicapa parva*, *Linota exilipes*, *Emberiza melanocephala*, *E. cirlus*, *E. rustica*, *E. pusilla*, *Pastor roseus*, and *Xema sabinii*. It is well known that large numbers of European birds, presumably driven out of their course, are seen during the autumn migration far out over the Atlantic, alighting on the ocean-going steamers. It is proposed by Mr. Harvie-Brown to supply schedules to the principal lines of ocean steam-vessels for the better recording of these occurrences. It must be borne in mind that the immense and constantly-increasing traffic which in these days bridges the Atlantic and unites the Old and New Worlds, offers unusual chances for birds to break their flight, and ultimately, perhaps, to reach the American coast. In the comparatively narrow seas between the European continent and Great Britain birds are frequently noted as alighting on the rigging of vessels and lightships, roosting in the rigging during the night, to resume their flight at the first streak of dawn. It is a matter of congratulation that our American and Canadian fellow-workers have instituted a similar system of observation on the migration of birds. At the first Congress of the American Ornithologists' Union, held at New York City, September 26 to 28, 1883, a Committee on the Migration of Birds was appointed. It is intended to investigate this in all its bearings and to the fullest possible extent, not only in the accumulation of records of the times of arrival and departure of the different species, but to embrace the collection of all data that may aid in determining the causes which influence migration from season to season. Your Committee respectfully request their reappointment, and trust that the Association will enable them to continue the collection of facts.

Tenth Report of the Committee, consisting of Prof. E. Hull, the Rev. H. W. Crosskey, and Messrs. James Glaisher, H. Marten, E. B. Marten, G. H. Morton, W. Pengelly, James Plant, I. Roberts, Thos. S. Stooke, G. J. Symons, W. Topley, E. Wethered, W. Whitaker, and C. E. De Rance (Secretary and Reporter), appointed for the Purpose of Investigating the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water Supplied to Various Towns and Districts from those Formations. Drawn up by C. E. De Rance.—The Chairman and Secretary of your Committee are both unavoidably obliged to be absent from the Montreal meeting, which is a source of regret to themselves; the more so that, this being the case, it has been thought advisable to delay presenting their final Report on the Circulation of Underground Waters in South Britain until next year, when the Committee will have been twelve years in existence. During these years particulars have been collected

of the sections passed through by a very large number of wells and borings; a daily record has been obtained of the height at which water stands in many of these wells; investigations have been carried out as to the quantity of water held by a cubic foot of various rocks, by Mr. Wethered; and as to the filtering power of sandstones, and the influence of barometric pressure and lunar changes on the height of underground waters, by Mr. I. Roberts. During the present year the attention of the Committee has been directed to the remarkable influence of the earthquake which visited the East and East-Central Counties of England in March last, in raising the levels of the water in the wells of Colchester and elsewhere. More detailed information is still required as to the proportion of actual rainfall absorbed by various soils, over extended periods representing typical dry and wet years. Information on these heads and on other points of general interest bearing on the percolation of underground waters, referring to observations made in Canada or the United States, would be gladly welcomed by the Committee, and would be incorporated in their eleventh and final Report to be presented next year. Your Committee seek reappointment, but do not require a grant, as they have forms of inquiry on hand, and did not require to expend the whole of the grant of last year, a portion of which only has been drawn.

Appendix—Copy of Questions.—1. *Position* of well or shafts with which you are acquainted. 1*a*. State *date* at which the well or shaft was originally sunk. Has it been deepened since by sinking or boring? and when? 2. Approximate *height* of the surface of the ground above Ordnance Datum (mean sea-level). 3. *Depth* from the surface to bottom of shaft or well, with diameter. *Depth* from surface to bottom of bore-hole, with diameter. 3*a*. *Depth* from the surface to the horizontal drift-ways, if any. What is their length and number? 4. *Height* below the surface at which water stands *before* and *after* pumping. Number of hours elapsing before ordinary level is restored after pumping. 4*a*. *Height* below the surface at which the water stood when the well was first sunk, and height at which it stands now when not pumped. 5. *Quantity* capable of being pumped in gallons per day of twenty-four hours. Average quantity daily pumped. 6. Does the *water-level* vary at different seasons of the year, and to what extent? Has it diminished during the last ten years? 7. Is the ordinary *water-level* ever affected by local rains, and, if so, in how short a time? And how does it stand in regard to the level of the water in the neighbouring streams, or sea? 8. *Analysis* of the water, if any. Does the water possess any marked *peculiarity*? 9. *Section*, with nature of the rock passed through, including cover of Drift, if any, with *thickness*. 9*a*. In which of the above rocks were springs of water intercepted? 10. Does the cover of Drift over the rock contain *surface springs*? 11. If so, are these *land springs* kept entirely *out* of the well? 12. Are any large *faults* known to exist close to the well? 13. Were any *brine springs* passed through in making the well? 14. Are there any *salt springs* in the neighbourhood? 15. Have any wells or borings been discontinued in your neighbourhood in consequence of the water being more or less *brackish*? If so, please give section in reply to query No. 9. 16. Kindly give any further information you can.

PENDING PROBLEMS OF ASTRONOMY[1]

THIRTY-SIX years ago this very month, in this city, and near the place where we are now assembled, the American Association for the Advancement of Science was organised, and held its first meeting. Now, for the first time, it revisits its honoured birthplace.

Few of those present this evening were, I suppose, in attendance upon that first meeting. Here and there, among the members of the Association, I see, indeed, the venerable faces of one and another, who, at that time in the flush and vigour of early manhood, participated in its proceedings and discussions; and there are others, who, as boys or youths, looked on in silence, and listening to the words of Agassiz and Peirce, of Bache and Henry, and the Rogers brothers and their associates, drank in that inspiring love of truth and science which ever since has guided and impelled their lives. Probably enough, too, there may be among our hosts in the audience a few who remember that occasion, and were present as spectators.

[1] Address to the American Association for the Advancement of Science at Philadelphia, September 5, by Prof. C. A. Young, Professor of Astronomy at Princeton, retiring President of the Association. We are indebted to the courtesy of the editor of *Science* for an early copy of Prof. Young's address.

But, substantially, we who meet here to-day are a new generation, more numerous certainly, and in some respects unquestionably better equipped for our work, than our predecessors were, though we might not care to challenge comparisons as regards native ability, or clearness of insight, or lofty purpose.

And the face of science has greatly changed in the meantime; as much, perhaps, as this great city and the nation. One might almost say, that, since 1848, "all things have become new" in the scientific world. There is a new mathematics and a new astronomy, a new chemistry and a new electricity, a new geology and a new biology. Great voices have spoken, and have transformed the world of thought and research as much as the material products of science have altered the aspects of external life. The telegraph and dynamo-machine have not more changed the conditions of business and industry than the speculations of Darwin and Helmholtz and their compeers have affected those of philosophy and science.

But, although this return to our birthplace suggests retrospections and comparisons which might profitably occupy our attention for even a much longer time than this evening's session, I prefer, on the whole, to take a different course; looking forwards rather than backwards, and confining myself mainly to topics which lie along the pathway of my own line of work.

The voyager upon the Inland Sea of Japan sees continually rising before him new islands and mountains of that fairy-land. Some come out suddenly from behind nearer rocks or islets, which long concealed the greater things beyond; and some are veiled in clouds which give no hint of what they hide, until a breeze rolls back the curtain; some, and the greatest of them all, are first seen as the minutest specks upon the horizon, and grow slowly to their final grandeur. Even before they reach the horizon line, while yet invisible, they sometimes intimate their presence by signs in sky and air; so slight, indeed, that only the practised eye of the skilful sailor can detect them, though quite obvious to him.

Somewhat so, as we look forward into the future of a science, we see new problems and great subjects presenting themselves. Some are imminent and in the way,—they must be dealt with at once, before further progress can be made; others are more remotely interesting in various degrees; and some, as yet, are mere suggestions, almost too misty and indefinite for steady contemplation.

With your permission, I propose this evening to consider some of the pending problems of astronomy,—those which seem to be most pressing, and most urgently require solution as a condition of advance; and those which appear in themselves most interesting, or likely to be fruitful, from a philosophic point of view.

Taking first those that lie nearest, we have the questions which relate to the dimensions and figure of the earth, the uniformity of its diurnal rotation, and the constancy of its poles and axis.

I think the impression prevails that we already know the earth's dimensions with an accuracy even greater than that required by any *astronomical* demands. I certainly had that impression myself not long ago, and was a little startled on being told by the superintendent of our "Nautical Almanac" that the remaining uncertainty was still sufficient to produce serious embarrassment in the reduction and comparison of certain lunar observations. The length of the line joining, say, the Naval Observatory at Washington with the Royal Observatory at the Cape of Good Hope is doubtful—not to the extent of only a few hundred feet, as commonly supposed, but the uncertainty amounts to some thousands of feet, and may possibly be a mile or more, probably not less than a ten-thousandth of the whole distance; and the *direction* of the line is uncertain in about the same degree. Of course, on those portions of either continent which have been directly connected with each other by geodetic triangulations, no corresponding uncertainty obtains; and as time goes on, and these surveys are extended, the form and dimensions of each continuous land-surface will become more and more perfectly determined. But at present we have no satisfactory means of obtaining the desired accuracy in the relative position of places separated by oceans, so that they cannot be connected by chains of triangulation. Astronomical determinations of latitude and longitude do not meet the case; since, in the last analysis, they only give at any selected station the *direction of gravity* relative to the axis of the earth, and some fixed meridian plane, and do not furnish any *linear* measurement or dimension.

Of course, if the surface of the earth were an exact spheroid, and if there were no irregular attractions due to mountains and valleys and the varying density of strata, the difficulty could be

easily evaded; but, as the matter stands, it looks as if nothing short of a complete geodetic triangulation of the whole earth would ever answer the purpose,—a triangulation covering Asia and Africa, as well as Europe, and brought into America by way of Siberia and Behring's Straits.

It is indeed theoretically possible, and just conceivable, that the problem may some day be reversed, and that the geodesist may come to owe some of his most important data to the observers of the lunar motions. When the relative position of two or more remote observatories shall have been precisely determined by triangulation (for instance, Greenwich, Madras, and the Cape of Good Hope), and when, by improved methods, and observations made at these fundamental stations, the moon's position and motion relative to them shall have been determined with an accuracy much exceeding anything now attainable, then by similar observations, made simultaneously at any station in this hemisphere, it will be theoretically possible to determine the position of this station, and so, by way of the moon, to bridge the ocean, and ascertain how other stations are related to those which were taken as primary. I do not, of course, mean to imply that, in the *present state* of observational astronomy, any such procedure would lead to results of much value; but, before the Asiatic triangulation meets the American at Behring's Straits, it is not unlikely that the accuracy of lunar observations will be greatly increased.

The present uncertainty as to the earth's dimensions is not, however, a sensible embarrassment to astronomers, except in dealing with the moon, especially in attempting to employ observations made at remote and ocean-separated stations for the determination of her parallax.

As to the form of the earth, it seems pretty evident that before long it will be wise to give up further attempts to determine exactly what spheroid or ellipsoid *most nearly corresponds* to the actual figure of the earth, since every new continental survey will require a modification of the elements of this spheroid in order to take account of the new data. It will be better to assume some closely approximate spheroid *as a finality;* its elements to be for ever retained unchanged, while the deviations of the actual surface from this ideal standard will be the subject of continued investigation and measurement.

A more important and anxious question of the modern astronomer is, whether is the earth's rotation uniform, and, if not, in what way and to what extent does it vary? The importance, of course, lies in the fact that this rotation furnishes our fundamental measure and unit of time.

Up to a comparatively recent date, there has not been reason to suspect this unit of any variation sufficient to be detected by human observation. It has long been perceived, of course, that any changes in the earth's form or dimensions must alter the length of the day. The displacement of the surface or strata by earthquakes or by more gradual elevation and subsidence, the transportation of matter towards or from the equator by rivers or ocean-currents, the accumulation or removal of ice in the Polar regions or on mountain-tops,—any such causes must necessarily produce a real effect. So, also, must the friction of tides and trade-winds. But it has been supposed that these effects were so minute, and to such an extent mutually compensatory, as to be quite beyond the reach of observation; nor is it yet certain that they are not. All that can be said is, that it is now beginning to be *questionable* whether they are or are not.

The reason for suspecting perceptible variation in the earth's revolution, lies mainly in certain unexplained irregularities in the apparent motions of the moon. She alone, of all the heavenly bodies, changes her place in the sky so rapidly that minute inaccuracies of a second or two in the time of observation would lead to sensible discrepancies in the observed position; an error of one second, in the time, corresponding to about half a second in her place,—a quantity minute, certainly, but perfectly observable. No other heavenly body has an apparent movement anywhere nearly as rapid, excepting only the inner satellite of Mars; and this body is so minute that its accurate observation is impracticable, except with the largest telescopes, and at the times when Mars is unusually near the earth.

Now, of late, the motions of the moon have been very carefully investigated, both theoretically and observationally; and, in spite of everything, there remain discrepancies which defy explanation. We are compelled to admit one of three things,—either the lunar theory is in some degree mathematically incomplete, and fails to represent accurately the gravitational action of the earth and sun, and other known heavenly bodies, upon her movements; or some unknown force other than the gravitational attractions of these bodies is operating in the case; or else, finally, the earth's rotational motion is more or less irregular, and so affects the time-reckoning, and confounds prediction.

If the last is really the case, it is in some sense a most discouraging fact, necessarily putting a limit to the accuracy of all prediction, unless some other unchanging and convenient measure of time shall be found to replace the "day" and "second."

The question at once presents itself, How can the constancy of the day be tested? The lunar motions furnish grounds of suspicion, but nothing more; since it is at least as likely that the mathematical theory is minutely incorrect or incomplete as that the day is sensibly variable.

Up to the present time the most effective tests suggested are from the transits of Mercury and from the eclipses of Jupiter's satellites. On the whole, the result of Prof. Newcomb's elaborate and exhaustive investigation of all the observed transits, together with all the available eclipses and occultations of stars, tends rather to establish the sensible constancy of the day, and to make it pretty certain (to use his own language) that "inequalities in the lunar motions, not accounted for by the theory of gravitation, really exist, and in such a way that the mean motion of the moon between 1800 and 1875 was really less (*i.e.* slower) than between 1720 and 1800." Until lately, the observations of Jupiter's satellites have not been made with sufficient accuracy to be of any use in settling so delicate a question; but at present the observation of their eclipses is being carried on at Cambridge, Mass., and elsewhere, by methods that promise a great increase of accuracy over anything preceding. Of course, no *speedy* solution of the problem is possible through such observations, and their result will not be so free from mathematical complications as desirable,—complications arising from the mutual action of the satellites, and the ellipsoidal form of the planet. On account of its freedom from all sensible disturbances, the remote and lonely satellite of Neptune may possibly some time contribute useful data to the problem.

We have not time, and it lies outside my present scope, to discuss whether, and, if so, how, it may be possible to find a unit of time (and length) which shall be independent of the earth's conditions and dimensions (free from all *local considerations*), cosmical, and as applicable in the planetary system of the remotest star as in our own. At present we can postpone its consideration; but the time must unquestionably come when the accuracy of scientific observation will be so far increased that the irregularities of the earth's rotation, produced by the causes alluded to a few minutes ago, will protrude, and become intolerable. Then a new unit of time will have to be found for scientific purposes, founded, perhaps, as has been already suggested by many physicists, upon the vibrations or motion of light, or upon some other physical action which pervades the universe.

Another problem of terrestrial astronomy relates to the constancy of the position of the earth's axis in the globe. Just as displacements of matter upon the surface or in the interior of the earth would produce changes in the time of rotation, so also would they cause corresponding alterations in the position of the axis and in the places of the poles,—changes certainly very minute. The only question is, whether they are so minute as to defy detection. It is easy to see that any such displacements of the earth's axis will be indicated by changes in the *latitudes* of our observatories. If, for instance, the Pole were moved a hundred feet from its present position, towards the continent of Europe, the latitudes of European observatories would be increased about one second, while in Asia and America the effects would be trifling.

The only observational evidence of such movements of the Pole, which thus far amounts to anything, is found in the results obtained by Nyren in reducing the determinations of the latitude of Pulkowa, made with the great vertical circle, during the last twenty-five years. They seem to show a slow, steady diminution of the latitude of this Observatory, amounting to about a second in a century; as if the North Pole were drifting away, and increasing its distance from Pulkowa at the rate of about one foot a year.

The Greenwich and Paris observations do not show any such result; but they are not conclusive, on account of the difference of longitude, to say nothing of their inferior precision. The question is certainly a doubtful one; but it is considered of so

much importance, that, at the meeting of the International Geodetic Association in Rome last year, a resolution was adopted recommending observations specially designed to settle it. The plan of Sig. Fergola, who introduced the resolution, is to select pairs of stations, having nearly the same latitude, but differing widely in longitude, and to determine the *difference* of their latitudes by observations of the same set of stars, observed with similar instruments, in the same manner, and reduced by the same methods and formulæ. So far as possible, the same observers are to be retained through a series of years, and are frequently to change stations when practicable, so as to eliminate personal equations. The main difficulty of the problem lies, of course, in the minuteness of the effect to be detected; and the only hope of success lies in the most scrupulous care and precision in all the operations involved.

Other problems, relating to the rigidity of the earth and its internal constitution and temperature, have, indeed, astronomical bearings, and may be reached to some extent by astronomical methods and considerations; but they lie on the border of our science, and time forbids anything more than their mere mention here.

If we consider, next, the problems set us by the moon, we find them numerous, important, and difficult. A portion of them are purely mathematical, relating to her orbital motion; while others are physical, and have to do with her surface, atmosphere, heat, &c.

As has been already intimated, the lunar theory is not in a satisfactory state. I do not mean, of course, that the moon's deviations from the predicted path are gross and palpable,—such, for instance, as could be perceived by the unaided eye (this I say for the benefit of those who otherwise might not understand now small a matter sets astronomers grumbling),—but they are large enough to be easily observable, and even obtrusive, amounting to several seconds of arc, or miles of space. As we have seen, the attempt to account for them by the irregularity of the earth's rotation has apparently failed; and we are driven to the conclusion, either that other forces than gravitation are operative upon the lunar motions, or else (what is far more probable, considering the past history of theoretical astronomy) that the mathematical theory is somewhere at fault.

To one looking at the matter a little from the outside, it seems as if that which is most needed just now, in order to secure the advance of science in many directions, is a new, more comprehensive, and more manageable solution of the fundamental equations of motion under attraction. Far be it from me to cry out against those mathematicians who delight themselves in transcendental and *n*-dimensional space, and revel in the theory of numbers,—we all know how unexpectedly discoveries and new ideas belonging to one field of science find use and application in widely different regions,—but I own I feel much more interest in the study of the theory of functions and differential equations, and expect more aid for astronomy from it.

The problem of any number of bodies, moving under their mutual attraction, according to the Newtonian laws, stands, from a physical point of view, on precisely the same footing as that of *two* bodies. Given the masses, and the positions and velocities corresponding to any moment of time, then the whole configuration of the system for all time, past and future (abstracting outside forces, of course), is absolutely determinate, and amenable to calculation. But while, in the case of *two* bodies, the calculation is easy and feasible, by methods known for two hundred years, our analysis has not yet mastered the general problem for more than two. In special instances, by computations, tedious, indirect, and approximate, we can, indeed, carry our predictions forward over long periods, or indicate past conditions with any required degree of accuracy; but a general and universally practicable solution is yet wanting. The difficulties in the way are purely mathematical: a step needs to be taken, corresponding in importance to the introduction of the circular functions into trigonometry, the invention of logarithms, or the discovery of the calculus. The problem confronts the astronomer on a hundred different roads; and, until it is overcome, progress in these directions must be slow and painful. One could not truly say, perhaps, that the lunar theory must, in the meanwhile, remain quite at a standstill: labour expended in the old ways, upon the extension and development of existing methods, may not be fruitless, and may, perhaps, after a while, effect the reconcilement of prediction and observation far beyond the present limits of accuracy. But if we only had the mathematical powers we long for, then progress would be as by wings: we should fly, where now we crawl.

As to the physical problems presented by the moon, the questions relating to the light and heat—the radiant energy—it sends us, and to its temperature, seem to be the most attractive at present, especially for the reason that the results of the most recent investigators seem partially to contradict those obtained by their predecessors some years ago. It now looks as if we should have to admit that nearly all we receive from the moon is simply *reflected* sunlight and sun-heat, and that the temperature of the lunar surface nowhere rises as high as the freezing-point of water, or even of mercury. At the same time, some astronomers of reputation are not disposed to admit such an upsetting of long-received ideas; and it is quite certain that, in the course of the next few years, the subject will be carefully and variously investigated.

Closely connected with this is the problem of a lunar atmosphere—if, indeed, she has any.

Then there is the very interesting discussion concerning changes upon the moon's surface. Considering the difference between our modern telescopes and those employed fifty or a hundred years ago, I think it still far from certain that the differences between the representations of earlier and later observers necessarily imply any real alterations. But they, no doubt, render it considerably *probable* that such alterations have occurred, and are still in progress; and they justify a persistent, careful, minute, and thorough study of the details of the lunar surface with powerful instruments: especially do they inculcate the value of large-scale photographs, which can be preserved for future comparison as unimpeachable witnesses.

I will not leave the moon without a word in respect to the remarkable speculations of Prof. George Darwin concerning the tidal evolution of our satellite. Without necessarily admitting all the numerical results as to her age and her past and future history, one may certainly say that he has given a most plausible and satisfactory explanation of the manner in which the present state of things might have come about through the operation of causes known and recognised, has opened a new field of research, and shown the way to new dominions. The introduction of the doctrine of the conservation of energy, as a means of establishing the conditions of motion and configuration in an astronomical system, is a very important step.

In the planetary system we meet, in the main, the same problems as those that relate to the moon, with a few cases of special interest.

For the most part, the accordance between theory and observation in the motions of the larger planets is as close as could be expected. The labours of Leverrier, Hill, Newcomb, and others, have so nearly cleared the field, that it seems likely that several decades will be needed to develop discrepancies sufficient to furnish any important corrections to our present tables. Leverrier himself, however, indicated one striking and significant exception to the general tractableness of the planets. Mercury, the nearest to the sun, and the one, therefore, which ought to be the best behaved of all, is rebellious to a certain extent: the perihelion of its orbit moves around the sun more rapidly than can be explained by the action of the other known planets. The evidence to this effect has been continually accumulating ever since Leverrier first announced the fact, some thirty years ago; and the recent investigation by Prof. Newcomb, of the whole series of observed transits, puts the thing beyond question. Leverrier's own belief (in which he died) was that the effect is due to an unknown planet or planets between Mercury and the sun; but, as things now stand, we think that any candid investigator must admit that the probability of the existence of any such body or bodies of considerable dimensions is vanishingly small. We do not forget the numerous instances of round spots seen on the solar disk, nor the eclipse-stars of Watson, Swift, Trouvelot, and others; but the demonstrated possibility of error or mistake in all these cases, and the tremendous array of negative evidence from the most trustworthy observers, with the best equipment and opportunity, makes it little short of certain that there is no Vulcan in the planetary system.

A ring of meteoric matter between the planet and the sun might account for the motion of the perihelion; but, as Newcomb has suggested, such a ring would also disturb the *nodes* of Mercury's orbit.

It has been surmised that the cause may be something in the distribution of matter within the solar globe, or some variation in gravitation from the exact law of the inverse square, or some supplementary electric or magnetic action of the sun, or some special effect of the solar radiation, sensible on account of the

planet's proximity, or something peculiar to the region in which the planet moves; but as yet no satisfactory explanation has been established.

Speaking of unknown planets, we are rather reluctantly obliged to admit that it is a part of our scientific duty as astronomers to continue to search for the remaining asteroids; at least, I suppose so, although the family has already become embarrassingly large. Still I think we are likely to learn as much about the constitution, genesis, and history of the solar system from these little flying rocks as from their larger relatives; and the theory of perturbations will be forced to rapid growth in dealing with the effects of Jupiter and Saturn upon their motions.

Nor is it unlikely that some day the searcher for these insignificant little vagabonds may be rewarded by the discovery of some great world, as yet unknown, slow moving in the outer desolation beyond the remotest of the present planetary family. Some configurations in certain cometary orbits, and some almost evanescent peculiarities in Neptune's motions, have been thought to point to the existence of such a world; and there is no evidence, nor even a presumption, against it.

Mercury as yet defies all our attempts to ascertain the length of its day, and the character and condition of its surface. Apparently the instruments and methods now at command are insufficient to cope with the difficulties of the problem; and it is not easy to say how it can be successfully attacked.

With Venus, the earth's twin sister, the state of things is a little better: we do already know, with some degree of approximation, her period of rotation; and the observations of the last few months bid fair, if followed up, to determine the position of her poles, and possibly to give us some knowledge of her mountains, continents, and seas.

It would be rash to say of Mars that we have reached the limit of possible knowledge as regards a planet's surface; but the main facts are now determined, and we have a rather surprising amount of supposed knowledge regarding its geography. By "supposed" I mean merely to insinuate a modest doubt whether some of the map-makers have not gone into a little more elaborate detail than the circumstances warrant. At any rate, while the "areographies" agree very well with each other in respect to the planet's more important features, they differ widely and irreconcilably in minor points.

As regards the physical features of the asteroids, we at present know practically nothing: the field is absolutely open. Whether it is worth anything may be a question; and yet, if one *could* reach it, I am persuaded that a knowledge of the substance, form, density, rotation, temperature, and other physical characteristics, of one of these little orphans would throw vivid light on the nature and behaviour of inter-planetary space, and would be of great use in establishing the physical theory of the solar system.

The planet Jupiter, lordliest of them all, still, as from the first, presents problems of the highest importance and interest. A sort of connecting-link between suns and planets, it seems as if, perhaps, we might find, in the beautiful and varied phenomena he exhibits, a kind of halfway house between familiar terrestrial facts and solar mysteries. It seems quite certain that no analogies drawn from the earth and the earth's atmosphere alone will explain the strange things seen upon his disk, some of which, especially the anomalous differences observed between the rotation periods derived from the observation of markings in different latitudes, are very similar to what we find upon the sun. "The great red spot" which has just disappeared, after challenging for several years our best endeavours to understand and explain it, still, I think, remains as much a mystery as ever,—a mystery probably hiding within itself the master-key to the constitution of the great orb of whose inmost nature it was an outward and most characteristic expression. The same characteristics are also probably manifested in other less conspicuous but equally curious and interesting markings on the varied and ever-changing countenance of this planet; so that, like the moon, it will well repay the most minute and assiduous study.

Its satellite system also deserves careful observation, especially in respect to the eclipses which occur; since we find in them a measure of the time required for light to cross the orbit of the earth, and so of the solar parallax, and also because, as has been already mentioned, they furnish a test of the constancy of the earth's rotation. The photometric method of observing these eclipses, first instituted by Prof. Pickering at Cambridge in 1878, and since re-invented by Cornu in Paris, has already much increased the precision of the results.

With reference to the mathematical theory of the motion of these satellites, the same remarks apply as to the planetary theory. As yet nothing appears in the problem to be beyond the power and scope of existing methods, when carried out with the necessary care and prolixity; but a new and more compendious method is most desirable.

The problems of Saturn are much the same as those of Jupiter, excepting that the surface and atmospheric phenomena are less striking, and more difficult of observation. But we have, in addition, the wonderful rings, unique in the heavens, the loveliest of all telescopic objects, the type and pattern, I suppose, of world-making, in actual progress before our eyes. There seems to be continually accumulating evidence from the observations of Struve, Dawes, Henry, and others, that these whirling clouds are changing in their dimensions and in the density of their different parts; and it is certainly the duty of every one who has a good telescope, a sharp eye, and a chastened imagination, to watch them carefully, and set down exactly what he sees. It may well be that even a few decades will develop most important and instructive phenomena in this gauzy girdle of old Chronos. Great care, however, is needed in order not to mistake fancies and illusions for solid facts. Not a few anomalous appearances have been described and commented on, which failed to be recognised by more cautious observers with less vivid imaginations, more trustworthy eyes, and better telescopes.

The outer planets, Uranus and Neptune, until recently, have defied all attempts to study their surface and physical characteristics. Their own motions and those of their satellites, have been well worked out; but it remains to discuss their rotation, topography, and atmospheric peculiarities. So remote are they, and so faintly illuminated, that the task seems almost hopeless; and yet, within the last year or two, some of our great telescopes have revealed faint and evanescent markings upon Uranus, which may in time lead to some further knowledge of that far-off relative. It may, perhaps, be that some great telescope of the future will give us some such views of Neptune as we now get of Jupiter.

There is a special reason for attempts to determine the rotation periods of the planets, in the fact that there is very possibly some connection between these periods on the one hand, and, on the other, the planets' distances from the sun, their diameters and masses. More than thirty years ago, Prof. Kirkwood supposed that he had discovered the relation in the analogy which bears his name. The materials for testing and establishing it were then, however, insufficient, and still remain so, leaving far too many of the data uncertain and arbitrary. Could such a relation be discovered, it could hardly fail to have a most important significance with respect to theories of the origin and development of the planetary system.

The great problem of the absolute dimensions of our system is, of course, commanded by the special problem of the solar parallax; and this remains a problem still. Constant errors of one kind or another, the origin of which is still obscure, seem to affect the different methods of solution. Thus, while experiments upon the velocity of light and heliometric measurements of the displacements of Mars among the stars agree remarkably in assigning a smaller parallax (and greater distance of the sun) than seems to be indicated by the observations of the late transits of Venus, and by methods founded on the lunar motions, on the other hand, the meridian observations of Mars all point to a larger parallax and smaller distance. While still disposed to put more confidence in the methods first named, I, for one, must admit that the margin of probable error seems to me to have been rather increased than diminished by the latest published results deduced from the transits. I do not feel so confident of the correctness of the value 8"·80 for the solar parallax as I did three years ago. In its very nature, this problem is one, however, that astronomers can never have done with. So fundamental is it, that the time will never come when they can properly give up the attempt to increase the precision of their determination, and to test the received value by every new method that may be found.

The problems presented by the sun alone might themselves well occupy more than the time at our disposal this evening. Its mass, dimensions, and motions, as a whole, are, indeed, pretty well determined and understood; but when we come to questions relating to its constitution, the cause and nature of the appearances presented upon its surface, the periodicity of its spots, its temperature, and the maintenance of its heat, the extent of its atmosphere, and the nature of the corona, we find the most radical differences of opinion.

The difficulties of all solar problems are, of course, greatly

enhanced by the enormous difference between solar conditions and the conditions attainable in our laboratories. We often reach, indeed, similarity sufficient to establish a bond of connection, and to afford a basis for speculation; but the dissimilarity remains so great as to render quantitative calculations unsafe, and make positive conclusions more or less insecure. We can pretty confidently infer the presence of iron and hydrogen and other elements in the sun by appearances which we can reproduce upon the earth; but we cannot safely apply empirical formulæ (like that of Dulong and Petit, for instance), deduced from terrestrial experiments, to determine solar temperatures: such a proceeding is an unsound and unwarrantable extrapolation, likely to lead to widely erroneous conclusions.

For my own part, I feel satisfied as to the substantial correctness of the generally received theory of the sun's constitution, which regards this body as a great ball of intensely heated vapours and gases, clothed outwardly with a coat of dazzling clouds formed by the condensation of the less volatile substances into drops and crystals like rain and snow. Yet it must be acknowledged that this hypothesis is called in question by high authorities, who maintain, with Kirchoff and Zöllner, that the visible photosphere is no mere layer of clouds, but either a solid crust, or a liquid ocean of molten metals; and there may be some who continue to hold the view of the elder Herschel (still quoted as authoritative in numerous school-books), that the central core of the sun is a solid and even habitable globe, having the outer surface of its atmosphere covered with a sheet of flame maintained by some action of the matter diffused in the space through which the system is rushing. We must admit that the question of the sun's constitution is not yet beyond debate.

And not only the constitution of the sun itself, but the nature and condition of the matter composing it, is open to question. Have we to do with iron and sodium and hydrogen as we know them on the earth, or are the solar substances in some different and more elemental state?

However confident many of us may be as to the general theory of the constitution of the sun, very few, I imagine, would maintain that the full explanation of sun-spots and their behaviour has yet been reached. We meet continually with phenomena, which, if not really contradictory to prevalent ideas, at least do not find in them an easy explanation.

So far as mere visual appearances are concerned, I think it must be conceded that the most natural conception is that of a dark chip or scale thrown up from beneath, like scum in a cauldron, and floating, partly submerged, in the blazing flames of the photosphere which overhang its edges, and bridge across it, and cover it with filmy veils, until at last it settles down again and disappears. It hardly *looks* like a mere hollow filled with cooler vapour, nor is its appearance that of a cyclone seen from above. But then, on the other hand, its spectrum under high dispersion is very peculiar, not at all that of a solid, heated slag, but it is made up of countless fine dark lines, packed almost in contact, showing, however, here and there, a bright line, or at least an interspace where the rank is broken by an interval wider than that which elsewhere separates the elementary lines,—a spectrum which, so far as I know, has not yet found an analogue in any laboratory experiment. It seems, however, to belong to the type of absorption spectra, and to indicate, as the accepted theory requires, that the spot is dark in consequence of *loss* of light, and not from any original defect of luminosity. Here, certainly, are problems that require solution.

The problem of the sun's peculiar rotation and equatorial acceleration appears to me a most important one, and still unsolved. Probably its solution depends in some way upon a correct understanding of the exchanges of matter going on between the interior and the surface of the fluid, cooling globe. It is a significant fact (already alluded to) that a similar relation appears to hold upon the disk of Jupiter, the bright spots near the equator of the planet completing their rotation about five minutes more quickly than the great red spot which was forty degrees from the equator. It is hardly necessary to say that an astronomer, watching our terrestrial clouds from some external station (on the moon, for instance), would observe just the reverse. Equatorial clouds would complete their revolution *more* slowly than those in our own latitude. *Our* storms travel towards the east, while the volcanic dust from Krakatoa moved swiftly west. We may at least conjecture that the difference between different planets somehow turns upon the question whether the body whose atmospheric currents we observe is receiving more heat from without than it is throwing off itself. Whatever may be the true explanation of this peculiarity in the motion of sun-spots, it will, when reached, probably carry with it the solution of many other mysteries, and will arbitrate conclusively between rival hypotheses.

The periodicity of the sun-spots suggests a number of important and interesting problems, relating, on the one hand, to its mysterious cause, and, on the other, to the possible effects of this periodicity upon the earth and its inhabitants. I am no "sun-spottist" myself, and am more than sceptical whether the terrestrial influence of sun-spots amounts to anything worth speaking of, except in the direction of magnetism. But all must concede, I think, that this is by no means yet demonstrated (it is not easy to prove a negative); and there certainly are facts and presumptions enough tending the other way to warrant more extended investigation of the subject. The investigation is embarrassed by the circumstance, pointed out by Dr. Gould, that the effects of sun-spot periodicity, if they exist at all (as he maintains they do), are likely to be quite different in different portions of the earth. The influence of changes in the amount of the solar radiation will, he says, be first and chiefly felt in alterations and deflections of the prevailing winds, thus varying the *distribution* of heat and rain upon the surface of the earth without necessarily much changing its *absolute amount*. In some regions it may, therefore, be warmer and drier during a sun-spot maximum, while in adjoining countries it is the reverse.

There can be no question that it is now one of the most important and pressing problems of observational astronomy to devise apparatus and methods delicate enough to enable the student to follow promptly and accurately the presumable changes in the daily, even the hourly, amounts of the solar radiation. It might, perhaps, be possible with existing instruments to obtain results of extreme value from observations kept up with persistence and scrupulous care for several years at the top of some rainless mountain, if such can be found; but the undertaking would be a difficult and serious affair, quite beyond any private means.

Related to this subject is the problem of the connection between the activity of the solar surface and magnetic disturbances on the earth,—a connection unquestionable as matter of fact, but at present unexplained as matter of theory. It may have something to do with the remarkable prominence of iron in the list of solar materials; or the explanation may, perhaps, be found in the mechanism by means of which the radiations of light and heat traverse inter-planetary space, presenting itself ultimately as a corollary of the perfected electro-magnetic theory of light.

The chromosphere and prominences present several problems of interest. One of the most fruitful of them relates to the spectroscopic phenomena at the base of the chromosphere, and especially to the strange differences in the behaviour of different spectrum-lines, which, according to terrestial observations, are due to the same material. Of two lines (of iron, for instance) side by side in the spectrum, one will glow and blaze, while the other will sulk in imperturbable darkness; one will be distorted and shattered, presumably by the swift motion of the iron vapour to which it is due, while the other stands stiff and straight.

Evidently there is some deep lying cause for such differences; and as yet no satisfactory explanation appears to me to have been reached, though much ingenious speculation has been expended upon it. Mr. Lockyer's bold and fertile hypothesis, already alluded to, that at solar and stellar temperatures our elements are decomposed into others more elemental yet, seems to have failed of demonstration thus far, and rather to have lost ground of late; and yet one is almost tempted to say, "It *ought* to be true," and to add that there is more than a possibility that its essential truth will be established some time in the future.

Probably all that can be safely said at present is, that the spectrum of a metallic vapour (iron, for instance, as before) depends not only upon the chemical element concerned, but also upon its physical conditions; so that, at different levels in the solar atmosphere, the spectrum of the iron will differ greatly as regards the relative conspicuousness of different lines; and so it will happen, that, whenever any mass of iron vapour is suffering disturbance, those lines only which particularly characterise the spectrum of iron in that special state will be distorted or reversed, while all their sisters will remain serene.

The problem of the solar corona is at present receiving much attention. The most recent investigations respecting it—those of Dr. Huggins and Prof. Hastings—tend in directions

which appear to be diametrically opposite. Dr. Huggins considers that he has succeeded in photographing the corona in full sunshine, and so in establishing its objective reality as an immense solar appendage, sub-permanent in form, and rotating with the globe to which it is attached. One may call it "an atmosphere," if the word is not to be too rigidly interpreted. I am bound to say that plates which he has obtained do really show just such appearances as would be produced by such a solar appendage, though they are very faint and ghost-like. I may add further, that, from a letter from Dr. Huggins, recently received, I learn that he has been prevented from obtaining any similar plates in England this summer by the atmospheric haze, but that Dr. Woods, who has been provided with a similar apparatus, and sent to the Riffelberg in Switzerland, writes that he has "an assured success."

Our American astronomer, on the other hand, at the last eclipse (in the Pacific Ocean), observed certain phenomena which seem to confirm a theory he had formulated some time ago, and to indicate that the lovely apparition is an apparition only, a purely optical effect due to the *diffraction* (not *re*fraction, nor reflection either) of light at the edge of the moon—no more a solar appendage than a rainbow or a mock sun. There are mathematical considerations connected with the theory which may prove decisive when the paper of its ingenious and able proposer comes to be published in full. In the meantime it must be frankly conceded that the observations made by him are very awkward to explain on any other hypothesis.

Whatever may be the result, the investigation of the status and possible extent of a nebulous envelope around a sun or a star is unquestionably a problem of very great interest and importance. We shall be compelled, I believe, as in the case of comets, to recognise other forces than gravity, heat, and ordinary gaseous elasticity, as concerned in the phenomena. As regards the actual existence of an extensive gaseous envelope around the sun, I may add that other appearances than those seen at an eclipse seem to demonstrate it beyond question,—phenomena such as the original formation of clouds of incandescent hydrogen at high elevations, and the forms and motions of the loftiest prominences.

But of all solar problems, the one which excites the deepest and most general interest is that relating to the solar heat, its maintenance and its duration. For my own part, I find no fault with the solution proposed by Helmholtz, who accounts for it mainly by the slow contraction of the solar sphere. The only objection of much force is that it apparently limits the past duration of the solar system to a period not much exceeding some twenty millions of years, and many of our geological friends protest against so scanty an allowance. The same theory would give us, perhaps, half as much time for our remaining lifetime; but this is no objection, since I perceive no reason to doubt the final cessation of the sun's activity, and the consequent death of the system. But while this hypothesis seems fairly to meet the requirements of the case, and to be a necessary consequence of the best knowledge we can obtain as to the genesis of our system and the constitution of the sun itself, it must, of course, be conceded that it does not yet admit of any observational verification. No measurements within our power can test it, so far as we can see at present.

It may be admitted, too, that much can be said in favour of other theories; such as the one which attributes the solar heat to the impact of meteoric matter, and that other most interesting and ingenious theory of the late Sir William Siemens.

As regards the former, however, I see no escape from the conclusion, that, if it were exclusively true, the earth ought to be receiving, as was pointed out by the late Prof. Peirce, as much heat from meteors as from the sun. This would require the fall of a quantity of meteoric matter, more than sixty million times as much as the best estimates make our present supply, and such as could not escape the most casual observation, since it would amount to more than a hundred and fifty[1] tons a day on every square mile.

[1] In an article on astronomical collisions, published in the *North American Review* about a year ago, I wrongly stated the amount at fifty tons. There was some fatality connected with my calculations for that article. I gave the amount of heat due to the five hundred tons of meteoric matter which is supposed to fall daily on the earth with an average velocity of fifteen miles per second as fifty-three calories annually per square metre,—a quantity two thousand times too great. Probably the error would have been noticed if even the number given had not been so small, compared with the solar heat, as fully to justify my argument, which is only strengthened by the correction. I owe the correction to Prof. LeConte of California, who called my attention to the errors.

As regards the theory of Siemens, the matter has been, of late, so thoroughly discussed, that we probably need spend no time upon it here. To say nothing as to the difficulties connected with the establishment of such a far-reaching vortex as it demands, nor of the fact that the temperature of the sun's surface appears to be above that of the dissociation point of carbon compounds, and hence above their highest heat of combustion, it seems certainly demonstrated that matter of the necessary density could not exist in inter-planetary space without seriously affecting the planetary motions by its gravitating action as well as by its direct resistance; nor could the stellar radiations reach us, as they do, through a medium capable of taking up and utilising the rays of the sun in the way this theory supposes.

And yet I imagine that there is a very general sympathy with the feeling that led to the proposal of the theory,—an uncomfortable dissatisfaction with received theories, because they admit that the greater part of the sun's radiant energy is, speaking from a scientific point of view, simply wasted. Nothing like a millionth part of the sky, as seen from the sun, is occupied, so far as we can make out, by objects upon which its rays can fall: the rest is vacancy. If the sun sends out rays in all directions alike, not one of them in a million finds a target, or accomplishes any useful work, unless there is in space some medium to utilise the rays, or unknown worlds, of which we have no cognisance, beyond the stars.

Now, for my own part, I am very little troubled by accusations of wastefulness against Nature, or by demands for theories which will show what the human mind can recognise as "use" for all energy expended. Where I can perceive such use, I recognise it with reverence and gratitude, I hope; but the failure to recognise it in other cases creates in my mind no presumption against the wisdom of Nature, or against the correctness of an hypothesis otherwise satisfactory. It merely suggests human limitations and ignorance. How can one without sight understand what a telescope is good for?

At the same time, perhaps we assume with a little too much confidence that, in free space, radiation does take place equally in all directions. Of course, if the received views as to the nature and conduct of the hypothetical "ether" are correct, there is no possibility of questioning the assumption; but, as Sir John Herschel and others have pointed out, the properties which must be ascribed to this "ether," to fit it for its various functions, are so surprising and almost inconceivable, that one may be pardoned for some reserve in accepting it as a finality. At any rate, as a fact, the question is continually started (the idea has been brought out repeatedly, in some cases by men of real and recognised scientific and philosophic attainment), whether the constitution of things may not be such that radiation and transfer of energy can take place only between ponderable masses; and that, too, without the expenditure of energy upon the transmitting-agent (if such exist) along the line of transmission, even *in transitu*. If this were the case, then the sun would send out its energy only to planets and meteors and sister-stars, wasting none in empty space; and so its loss of heat would be enormously diminished, and the time-scale of the life of the planetary system would be correspondingly extended. So far as I know, no one has ever yet been able to indicate any kind of medium or mechanism by which vibrations, such as we know to constitute the radiant energy of light and heat, can be transmitted at all from sun to planet under such restrictions. Still one ought not to be too positive in assertions as to the real condition and occupancy of so-called vacant space. The "ether" is a good working hypothesis, but hardly more as yet.

I need not add that a most interesting and as yet inaccessible problem, connected with the preceding, is that of the mechanism of gravitation, and, indeed, of all forces that seem to act at a distance; as, for that matter, in the last analysis, *all* forces do. If there really be an "ether," then it would seem that somehow all attractions and repulsions of ponderable matter must be due to its action. Challis's investigations and conclusions as to the effect of hydrodynamic actions in such a medium do not seem to have commanded general acceptance; and the field still lies open for one who will show how gravitation and other forces can be correlated with each other through the ether.

Meteors and comets, seeming to belong neither to the solar system nor to the stellar universe, present a crowd of problems as difficult as they are interesting. Much has undoubtedly been gained during the last few decades; but in some respects that which has been learned has only deepened the mystery.

The problem of the origin of comets has been supposed to be solved to a certain extent by the researches of Schiaparelli, Heis,

Prof. Newton, and others, who consider them to be strangers coming in from outer space, sometimes "captured" by planets, and forced into elliptic orbits, so as to become periodic in their motion. Certainly this theory has strong supports and great authority, and probably it meets the conditions better than any other yet proposed. But the objections are really great, if not insuperable,—the fact that we have so few, if any, comets moving in hyperbolic orbits, as comets *met* by the sun would be expected to move; that there seems to be so little relation between the direction of the major axis of cometary orbits and the direction of the solar motion in space; and especially the fact, pointed out and insisted upon by Mr. Proctor in a recent article, that the alteration of a comet's natural parabolic orbit to the observed elliptic one, by planetary action, implies a reduction of the comet's velocity greater than can be reasonably explained. If, for instance, Brorsen's comet (which has a mean distance from the sun a little more than three times that of the earth) was really once a parabolic comet, and was diverted into its present path by the attraction of Jupiter, as generally admitted, it must have had its velocity reduced from about eleven miles a second to five. Now, it is very difficult, if not out of the question, to imagine any possible configuration of the two bodies and their orbits which could result in so great a change. While I am by no means prepared to indorse as conclusive all the reasoning in the article referred to, and should be very far from ready to accept the author's alternative theory (that the periodic comets have been ejected from the planets, and so are not their captives, but their children), I still feel that the difficulty urged against the received theory is very real, and not to be evaded, though it may possibly be overcome by future research.

Still more problematical is the constitution of these strange objects of such enormous volume and inconceivable tenuity, self-luminous and transparent, yet reflecting light, the seat of forces and phenomena unparalleled in all our other experience. Hardly a topic relating to their appearance and behaviour can be named which does not contain an unsolved problem. The varying intensity, polarisation, and spectroscopic character of their light; the configurations of the nucleus and its surrounding nebulosity; and especially the phenomena of jets, envelopes, and tail,—all demand careful observation and thorough discussion.

I think it may be regarded as certain that the explanation of these phenomena when finally reached, if that time ever comes, will carry with it, and be based upon, an enormous increase in our knowledge as to the condition, contents, and temperature of inter-planetary space, and the behaviour of matter when reduced to lowest terms of density and temperature.

Time forbids any adequate discussion of the numerous problems of stellar astronomy. One work, in its very nature incessant and interminable, consists, of course, in the continual observation and cataloguing of the places of the stars, with ever-increasing precision. These star-places form the scaffold and framework of all other astronomical investigations involving the motions of the heavenly bodies: they are the reference-points and bench-marks of the universe. Ultimately, too, the comparison of catalogues of different dates will reveal the paths and motions of all the members of the starry host, and bring out the great orbit of the sun and his attendant planets.

Meanwhile, micrometic observations are in order, upon the individual stars in different clusters, to ascertain the motions which occur in such a case; and the mathematician is called upon again to solve the problem of such movement.

Now, too, since the recent work of Gill and Elkin in South Africa, and of Struve, Hall, and others, elsewhere, upon stellar parallax, new hopes arise that we may soon come to some wider knowledge of the subject; that, instead of a dozen or so parallaxes of doubtful precision, we may get a hundred or more relating to stars of widely different brightness and motion, and so be enabled to reach some trustworthy generalisations as to the constitution and dimensions of the stellar universe, and the actual rates of stellar and solar motion in space.

Most interesting, also, are the studies now so vigorously prosecuted by Prof. Pickering in this country, and many others elsewhere, upon the brightness of the stars, and the continual variations in this brightness. Since 1875, stellar photometry has become almost a new science.

Then there are more than a myriad of double and multiple stars to watch, and their orbits to be determined; and the nebulæ claim keen attention, since some of them appear to be changing in form and brightness, and are likely to reveal to us some wonderful secrets in the embryology of worlds.

Each star also presents a subject for spectroscopic study; for although, for the most part, the stars may be grouped into a very few classes from the spectroscopic point of view, yet, in detail, the spectra of objects belonging to the same group differ considerably and significantly, almost as much as human faces do.

For such investigations, new instruments are needed, of unexampled powers and accuracy, some for angular measurement, some for mere power of seeing. Photography comes continually more and more to the front; and the idea sometimes suggests itself that by and by the human eye will hardly be trusted any longer for observations of precision, but will be superseded by an honest, unprejudiced, and unimaginative plate and camera. The time is not yet, however, most certainly. Indeed, it can never come at all, as relates to certain observations; since the human eye and mind together integrate, so to speak, the impressions of many separate and selected moments into one general view, while the camera can only give a brutal copy of an un-elected state of things, with all its atmospheric and other imperfections.

New methods are also needed, I think (they are unquestionably possible), for freeing time-observations from the errors of personal equation; and increased precision is demanded, and is being progressively attained, in the prevention or elimination of instrumental errors, due to differences of temperature, to mechanical strains, and to inaccuracies of construction. Astronomers are now coming to the investigation of quantities so minute that they would be completely masked by errors of observation that formerly were usual and tolerable. The science has reached a stage, where, as was indicated at the beginning of this address, it has to confront and deal with the possible unsteadiness of the earth's rotation, and the instability of its axis. The astronomer has now to reverse the old maxim of the courts: for him, and most emphatically at present, *De minimis curat lex.* Residuals and minute discrepancies are the seeds of future knowledge, and the very foundations of new laws.

And now, in closing this hurried and inadequate, but I fear rather tedious, review of the chief problems that are at present occupying the astronomer, what answer can we give to him who insists, *Cui bono?* and requires a reason for the enthusiasm that makes the votaries of our science so ardent and tireless in its pursuit? Evidently very few of the questions which have been presented have much to do directly with the material welfare of the human race. It may possibly turn out, perhaps, that the investigation of the solar radiation, and the behaviour of sun-spots, may lead to some better understanding of terrestrial meteorology, and so aid agricultural operations and navigation. I do not say it will be so,—in fact, I hardly expect it,—but I am not sure it will not. Possibly, too, some few other astronomical investigations may facilitate the determination of latitudes and longitudes, and so help exploration and commerce; but, with a few exceptions, it must be admitted that modern astronomical investigations have not the slightest immediate commercial value.

Now, I am not one of those who despise a scientific truth or principle because it admits of an available application to the affairs of what is called "practical life," and so is worth something to the community in dollars and cents: its commercial value is—just what it is—to be accepted gratefully.

Indirectly, however, almost all scientific truth has real commercial value, because "knowledge is power," and because (I quote it not irreverently) "the truth shall make you free,"—any truth, and to some extent; that is to say, the intelligent and intellectually cultivated will generally obtain a more comfortable livelihood, and do it more easily, than the stupid and the ignorant. Intelligence and brains are most powerful allies of strength and hands in the struggle for existence; and so, on purely economical grounds, all kinds of science are worthy of cultivation.

But I should be ashamed to rest on this lower ground: the highest value of scientific truth is not economic, but different and more noble; and, to a certain and great degree, its truest worth is more as an object of pursuit than of possession. The "practical life"—the eating and the drinking, the clothing and the sheltering—comes *first*, of course, and is the necessary foundation of anything higher; but it is not the whole or the best or the most of life. Apart from all spiritual and religious considerations, which lie on one side of our relations in this Association, there can be no need, before this audience, to plead the higher rank of the intellectual, æsthetic, and moral life above the material, or to argue that the pabulum of the mind is worth

as much as food for the body. Now, I am sure I can safely assert that, in the investigation and discovery of the secrets and mysteries of the heavens, the human intellect finds most invigorating exercise, and most nourishing and growth-making aliment. What other scientific facts and conceptions are more effective in producing a modest, sober, truthful, and ennobling estimate of man's just place in Nature, both of his puny insignificance, regarded as a physical object, and his towering spirit, in some sense comprehending the universe itself, and so akin to the divine?

A nation bound to the dust, and near to starving, needs first, most certainly, the trades and occupations that will feed and clothe it. When bodily comfort has been achieved, then higher needs and wants appear; and then science, for truth's own sake, comes to be loved and honoured along with poetry and art, leading men into a larger, higher, and nobler life.

SCIENTIFIC SERIALS

THE *Journal of the Franklin Institute* for July contains:—How to determine the grade of expansion and the size of a steam-engine which is to perform a given duty with the least total expenditure of money per working hour, by L. D'Auria.—Present state of the subject: "Heat of combustion of coal," by Chief Engineer Isherwood, U.S.N. (with figures and tables).—New York to Chicago in seventeen hours, by W. Barnet Le Van (4 diagrams).—Electro-dynamics, by John W. Nystrom.—A short paper criticising Moncel's formulæ in "Electricity as a Motive Power."—The ellipticity of planets, by Pliny Earle Chase, LL.D.—The discharge of turbine water-wheels, by J. P. Frizell (with tables).—The iridium industry, by Wm. L. Dudley (illustrated).—Physical and chemical tests of steel for boiler and ship plates for the U.S. Government cruisers, by Pedro G. Salom (5 pages of tables).—To tell iron from steel in small pieces (translated from Dingler's *Polytechnisches Journal*, by W. F. Worthington, U.S.N.—Report on the trial of the "City of Fall River," by J. E. Sague, M.E., and J. B. Adger, M.E.—Correspondence.—Book Notices.—Franklin Institute.—Items.—Low temperatures.—Ventilation of sewers.—Marsnat's safety lamp.

Rivista Scientifico-Industriale, June and July.—Exposition of a new theory on the formation of hailstones; experiments on their artificial production, by Prof. Giovanni Luvini.—Remarks on radiant heat in connection with the second law of thermodynamics, by Prof. Adolfo Bartoli.—On the various hypotheses hitherto proposed to harmonise the results of the theory of radiation with the second law of thermodynamics, by the same author.—On Lambrecht's thermo-hygroscope, by the Editor.—Researches on the persistence of life and the vital functions in insects after decapitation, by Dante Roster.

Bulletin de l'Académie Royale de Belgique, June 7.—Obituary notice of M. F. Duprez, by M. Van der Mensbrugghe.—A contribution to the study of drinking-waters, and especially of those supplied to the city of Louvain, by M. Blas.—Researches on the germination of linseed and sweet almonds, by M. A. Jorissen.—On the Marine Station at Edinburgh, by MM. Van Beneden and Renard.—Note on a flint instrument discovered in the Quaternary alluvia of Hainaut in association with the remains of the mammoth, rhinoceros, and horse, by F. L. Cornet.—Discourse pronounced at the obsequies of M. Louis Hymans, by M. Wagener.—On gymnastic exercises in the Belgian educational establishments, by M. Vincent de Block.—On the poetical works of Jean d'Outremeuse, by M. Stanislas Bormans.

Archives des Sciences physiques et naturelles (de Genève), 3e periode, tomes ix. and x., 1883.—On electrolytic condensers, by C. E. Guillaume.—The determination of the absolute capacity of some condensers in electro-magnetic units, by M. Schneebeli.—On the theory of atmospheric absorption of solar radiation, by J. Maurer.—Note on cometary refraction, by G. Cellérier.—Researches on the absorption of ultra-violet rays by various bodies, by J. L. Soret.—Remarkable movements which sometimes follow the fall of hailstones and sleet, by D. Colladon.—Theory of dynamo-electric machinery, by R. Clausius.—Adjustment of resistance coils, by S. P. Thompson.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, September 8.—M. Rolland, President, in the chair.—The sitting was opened by the President with a few remarks on the ninety-ninth anniversary of M. Chevreul, *doyen* of the Academy.—Researches on the general development of vegetation in an annual plant (continued): nitrous elements and mineral constituents, by MM. Berthelot and André.—Note on the general resolution of the linear equation in matrices of any order, by Prof. Sylvester.—Remarks on balloon steering, by M. Duroy de Bruignac. The author considers that the experiment of August 9 at Chalais introduces a new phase of aërial navigation; and that the problem hitherto regarded as hopeless may soon be completely solved. It must, however, always remain of difficult application, the results depending on two essential conditions: that is, the necessity of increasing the propelling power and of diminishing the resistance of the air. A simple calculation shows that this resistance is in proportion to the cube of the sine in the angle of incidence of the prevailing atmospheric current. Hence for the small angles, which are rightly preferred, we get a variation of from 2° to 4° double or treble, or thereabouts, a tremendous obstacle, which has to be overcome.—Observations of the new Borelly planet 240, made at the Observatory of Algiers, by M. Ch. Trépied.—Observations of the solar spots and faculæ made at the Observatory of the Collegio Romano during the second quarter of the present year, by M. Tacchini.—A new contribution to the question of the origin of the phosphates of lime in the South-West of France, by M. Dieulafait. The author refers these formations to the action of saline waters during the Tertiary epoch, analogous to if not identical with those of the lagoons at the present time. The saline and concentrated waters of these lagoons, which certainly existed in Tertiary times, played a double part in the production of the natural phosphates of lime. In the first place they attacked the limestone rocks far more actively than ordinary water could have done; and then they contribute directly phosphoric acid, which is still being deposited in the shallow lagoons of the Rhone delta.—Experiments made for the purpose of testing the influence of pulps and other artificially prepared foods on cow's milk, by MM. A. Andouard and V. Dézaunay. These experiments, carried on during the years 1883 and 1884, tended to show that the prepared foods acted injuriously on the milk, but increased the quantity of butter without affecting its quality.—On the solar coronas recently observed in Switzerland, at Nice, and elsewhere, by M. L. Thollon. From a comparative study of the different accounts received of these phenomena, the author concludes that they are not merely halos, but true coronas, that is, an effect of diffraction produced either by fine dust or by light particles of moisture present in the elevated regions of the atmosphere.—Description of a meteor observed at the Trocadéro Observatory on the night of September 5, by M. L. Jaubert.

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